FLOOD DAMAGE REDUCTION
RECONNAISSANCE REPORT
SKAGIT RIVER, WASHINGTON
EXECUTIVE SUMMARY

This report presents the results of a reconnaissance study that was conducted under the authority of Section 209, Public Law 87-874 of the Flood Control Act of 1962. The primary purpose of the study was to determine if there is a Federal interest in pursuing feasibility-level flood damage reduction studies in the Skagit Basin in Skagit County, Washington.

This reconnaissance study finds that an economically feasible solution exists for flood damage reduction in the Skagit Basin. This solution includes a system of levees that would protect the towns of Burlington, Mount Vernon and West Mount Vernon, from flood events up to a 100 year frequency interval. Also, a series of new overtopping levee sections and upgraded existing levees would be constructed to ensure flood protection for up to a 25 year event. The plan would reduce average annual flood damages in the Skagit Basin by $4,872,000 (from $9,957,000 to $5,085,000) and would eliminate $459,000 in annual floodproofing expenditures associated

with future development. The benefit-to-cost ratio of this improvement is 1.1 to 1. These improvements would cost approximately $49,300,000, which would be cost-shared at roughly 25 percent non-Federal and 75 percent Federal. The environmental impacts for the urban levees would be relatively small, and impacts to the rural levees could be significantly reduced with adequate mitigation or avoidance in key areas and adverse impacts could be mitigated. The local sponsor, Skagit County, favors this plan as a basis for further evaluation and consideration of other alternatives in the subsequent feasibility phase. Skagit County is aware of the feasibility study and project cost sharing requirements of the project to be constructed, and have indicated their intent to satisfy those requirements. There is a Federal interest in pursuing further studies of flood damage reduction measures in the Skagit Basin.

SKAGIT RIVER
FLOOD DAMAGE REDUCTION
RECONNAISSANCE REPORT

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SECTION 1. INTRODUCTION

1.1 Authority. The Skagit River Flood Damage Reduction Study was authorized under Section 209 of the Flood Control Act of 1962, Public Law 87-874.

1.2 Study Purpose and Scope.

The purpose of this report is to present the results of a reconnaissance investigation addressing flood problems in the Skagit River Basin, WA. (See Plate 1 - Skagit River Basin).

The scope of this study is to identify problems, opportunities and potential solutions to flood problems within the Skagit River basin from the town of Sedro Woolley downstream 20 miles to the mouth of the Skagit River, to appraise the Federal interest, and to develop project costs and benefits. An appropriate balance of economic, environmental, and engineering considerations were evaluated in the alternatives considered. The level of detail presented in this study is limited to that necessary to establish if feasibility level planning studies should be conducted. Extensive use was made of existing data and information from prior studies and reports.

1.3 Study History

1.3.1 General.

The Skagit River valley has had a long history of flooding since the area was first settled in the mid-1800's. In the valley below Sedro Woolley, the maximum safe channel capacity varies from 100,000 cfs to 146,000 cfs. Since 1908, 100,000 cfs has been frequently exceeded during the winter floods, which normally occur from October through March. During the November 25-26, 1990 flood, the river peaked at 148,700 cfs at Concrete and 152,000 cfs (approximately a 35 year event) at Mount Vernon. Some flood protection is provided by a combination of upstream storage at hydroelectric projects and downstream local flood protection works. However, flood damages in the Skagit River Basin remain high. The November 1990 floods caused $39,800,000 in price updated damages in the lower basin with extensive damage to flood protective works, residential structures and agricultural lands and crops.

1.3.2 Summary of Previous Corps of Engineers Studies.

In the 1920's and 1930's two Army Corps of Engineers studies were authorized by Congress (HD 125, 69th Congress, 1st

Session and HD 157, 73d Congress, 2d Session) to evaluate the need for flood control projects along the Skagit. None were recommended until the Flood Control Act of 1936 authorized an Avon Bypass project to provide for diverting a portion of the Skagit River floodwaters between Burlington and Mount Vernon into Padilla Bay. In 1952, the project was classified inactive because the local participation requirements could not be met.

In 1966 Congress authorized (HD 483, 89th Congress, 2d Session) a reconsideration of the Avon Bypass project with levee and channel improvements along the Skagit River below Sedro Woolley and modification of the Avon Bypass to permit Federal participation in recreation facilities. A 1979 General Design Memorandum recommended an extensive levee system from Sedro Woolley, downstream 20 miles to the mouth of the Skagit River. The levees were to provide Standard Project Flood (SPF) protection to Mount Vernon; 100-year event protection to the communities of Sedro Woolley, Sterling, Burlington, Avon, and Clear Lake; and 50-year event protection in the remaining rural areas. The study was deferred after Skagit Basin residents failed to support a public bond issue to fund the proposal, and is in the process of being de-authorized.

In the 1970's the Corps of Engineers also participated in an interagency task force with the Pacific Northwest River Basins Commission under the authority of the Puget Sound and Adjacent Waters Comprehensive Study. In 1974 the study was transmitted to Congress with recommendations for additional flood control storage at the Upper Baker Project and construction of the previously authorized Avon Bypass and Skagit River Levee and Channel Improvement projects.   In 1977 the Corps of Engineers recommended and Congress authorized (House Document 149, 95th Congress, 1st Session) a plan to provide an additional 58,000 acre-feet of flood control storage in Upper Baker Dam for a total of 74,000 acre feet.

The Seattle District, Corps of Engineers initiated a Section 205 Flood Damage Reduction Study for West Mount Vernon in February of 1993. West Mount Vernon is connected to the main portion of the City of Mount Vernon by a State Highway 536 bridge. The western bank of the Skagit is leveed in this area, but there is a low spot just west of the bridge abutment.

During floods it has been the local practice to construct an earthen berm across this low point. As flooding continues, access to the state highway bridge can become cut off. Should the levees be breached, exits from West Mount Vernon would be cut off, posing hazards to life and property. Improvements to the West Mount Vernon levee system would be compatible with levee improvements proposed as part of this General Investigation Study and would reduce construction costs. This portion of the overall plan is being studied now because of the potential for significant loss of life without the proposed project. The proposed project in West Mount Vernon would be compatible with any conceivable plan for the overall basin.

Following the November 1990 floods, the Corps of Engineers and the Federal Emergency Management Agency (FEMA) completed approximately $5.5 million in levee repairs at 12 locations throughout the Skagit basin, primarily at Fir Island.

1.4 Study Sponsorship

The City of Mount Vernon, by letter dated September 22, 1988, requested Corps of Engineers assistance in providing a solution to the flooding problems for the city. By letter dated December 28, 1990, Skagit County officials requested a widening of the study scope to include a comprehensive basin-wide approach (See Appendix 1). Both sponsors have offered to share costs in accordance with the Water Resources Development Act of 1986 (Public Law 99-662). Significant local and Congressional expressions of interest have been made in various forms, especially after the devastating floods of November 1990. A Citizens Advisory Committee formed in 1992 meets monthly with the Corps of Engineers on the status of the reconnaissance study. Members include representatives from the Skagit Valley diking districts, valley cities of Skagit County and specially affected areas. The committee sponsored a workshop in 1993 in the Samish valley and attended a number of Corps and County-sponsored workshops throughout the basin. The Corps of Engineers has met repeatedly with all the diking districts.

The County Commissioners, the Citizens Advisory Committee and Skagit County staff have been briefed on the outcome of this reconnaissance study and fully support continuing into the feasibility phase. The County Commissioners' letter of April 15, 1993 shows their support for going into the next phase of the study (See Appendix 1).

SECTION 2. PLAN FORMULATION

2.1 Existing Conditions

2.1.1 General

The project location is the lower Skagit River in Skagit County, Washington. As shown in Plate 1, the Skagit River Basin is situated in the northwest corner of the State of Washington. The basin encompasses 3,140 square miles and extends about 110 miles in a north-south direction and approximately 90 miles in an east-west direction between the crest of the Cascade Mountains and Puget Sound. The northern end of the basin extends 28 miles into British Columbia, Canada. Within the United States, the Skagit River drainage basin lies south of the Nooksack River and north of the Stillaguamish and Snohomish Rivers. The Samish River Basin lies immediately north of the Skagit River and encompasses 106 square miles.

The entire floor of the Skagit River Valley and deltas of the Samish and Skagit Rivers comprise the flood plain. The flood plain covers approximately 96,000 acres; 74,000 acres are fertile delta land downstream and west of the City of Sedro Woolley; and 22,000 acres are river-bottom land east and upstream of the City. The major portion of the bottom land east of Sedro Woolley is developed farmsteads, and the remainder is mostly uncleared or swampy. Farms in the delta are highly developed and well maintained. The communities of Burlington, LaConner, Clear Lake, Avon, Conway, and Mount Vernon are situated principally on delta land.

2.1.2 Socioeconomics

The Skagit River Basin lies predominately in Skagit County. Skagit County is used as the basis for describing the socioeconomic environment due to the availability of data at the county level and because water resource development of the Skagit River would have an impact on a substantial portion of the residents and economic activities of the county.

Skagit County has a diversified economic base made up of agriculture, forest products, fisheries, food processing, oil refining and chemical industries. Employment by County, city, and some Federal agencies also contribute to the local economy. The largest farming area is west of Sedro Woolley, with about 60,000 acres of rich delta lands in the flood plain. Half of the agriculture industry is devoted to dairy producers, thus Skagit County is ranked fourth in the state in dollar value of dairy products sold. Migratory runs of salmon and steelhead provide a sport and commercial fishery resource. Plants in La Conner and Anacortes process commercial catches of fish. Forest resources provide logs that are trucked to pulp and lumber mills in Anacortes, Everett, and Bellingham. Logging restrictions resulting from environmental issues have sharply reduced employment in the forest products industry the last 10 years, however. Non-manufacturing employment in Skagit County grew by over 50 percent the last 15 years, with jobs in the trade and service sectors representing 51 percent of County-covered employment in 1990. County, city and Federal Government and manufacturing were the next largest employment categories, representing 20 and 15 percent, respectively, of total county employment in 1990.

During the 1970s and 1980s, Skagit County's population grew faster than both the state and national average, due to immigration of new residents, in part because the county serves as a bedroom community for the urban Everett area. Mount Vernon, the largest city in the county, was also the fastest growing, increasing at an average annual rate of 3.7 percent between 1970 and 1992, as shown on Table 1. Forecasts of population growth from the Skagit County Planning Department show county population at 131,885 by the year 2010, a 54 percent increase over 1992.

TABLE 1.
HISTORICAL POPULATION
WASHINGTON AND SKAGIT COUNTY

	1970	1980	1990	1992	Average Ann. Increase 1970-1992
Washington State	3,409,169	4,132,204	4,866,692	5,116,700	1.9%
Skagit County	52,381	64,138	79,555	85,500	2.3%
Unincorporated	26,403	30,292	38,183	40,500	2.0%
Towns of:					
Anacortes	7,701	9,013	11,451	12,110	2.1%
Burlington	3,138	3,894	4,349	4,690	1.8%
Concrete	573	592	735	730	1.1%
Hamilton	201	283	228	230	0.6%
La Conner	639	660	656	690	0.3%
Lyman	324	285	275	290	-0.5%
Mount Vernon	8,804	13,009	17,647	19,550	3.7%
Sedro Woolley	4,598	6,110	6,031	6,710	1.7%

Source: U.S. Bureau of Census, Census of Population

2.1.3 Cultural Resources.

Reconnaissance, survey, and excavation of historic and prehistoric cultural resources have been carried out sporadically in the Skagit Delta for 25 years. During the summer and fall of 1978, a cultural reconnaissance study was conducted by the Corps of Engineers along the Skagit River between Sedro Woolley and Skagit Bay. The reconnaissance identified 54 cultural resource sites in this area, 20 of which are prehistoric and 34 historic, including homesteads, cemeteries and other domestic, municipal and commercial locations. Several deeply buried "wet" sites have been found in the Skagit Delta. The oldest materials found so far in the Skagit Delta and vicinity are less than 5,000 years old. Permanent villages associated with several Salishan-speaking Indian groups were situated along the Skagit River, particularly near its mouth and at the outlet of sloughs, and on Skagit Bay.

Euro-American settlement did not begin until the late 1850's. Gold strikes in the 1870's brought in miners who turned to farming and logging after the gold gave out. Local diking districts built levees along the river to support agricultural use of lowlands through the late 1800's and into the first half of this century.

2.1.4 Native American Concerns. The study is in territories ceded in the Point Elliot Treaty Council of 1855 by the Lower and Upper Skagit Tribes of Indians. The Mount Vernon and Burlington area levee developments are in the Upper Skagit area and the Fir Island developments are in the Lower Skagit area. The Swinomish Indian Tribal Community near La Conner is the current political representative of the Lower Skagit Tribe. The Upper Skagit Tribe is seated at Sedro Woolley. The Sauk-Suiattle Tribe is located in Darrington near the Sauk River. All three tribes have usual and accustomed fishing places throughout the Skagit River. Past flood control activities have severely diminished the anadromous fisheries resources depended upon by the three tribes, and recent studies indicate that harvest opportunities for coho salmon have been reduced by half as a result of these activities. This has created severe economic impacts on the tribal economies.

2.1.5 Fish & Wildlife.

a. General. The following discussion reflects input from and coordination with the US Fish & Wildlife Service (FWS) Report (reference Appendix 5). The watershed of the Skagit River is over 3,000 square miles. The upper Skagit basin is in the

Cascade Mountain range (Washington and British Columbia) and has elevations of over 8,000 feet with narrow precipitous canyons. Much of the upper basin, above Marblemount, is publicly owned land contained in North Cascades National Park, Ross Lake National Recreation Area, Glacier Peak Wilderness and the Mt. Baker-Snoqualmie National Forest. In the mid to lower reaches of the basin, forest harvesting is practiced extensively. The lower Skagit valley, below Sedro Woolley, is a broad, generally flat flood plain with extensive agricultural development. The majority of the population, in the Skagit basin, lives in the low-lying flood plain.

The Skagit River basin is rich in natural resources. The upper to mid slopes are heavily forested with conifers and are prime habitat for many varieties of large mammals, birds and smaller mammals. There are still many natural wildlife habitat areas in the lower agricultural areas of the valley; along the river are forested riparian areas and wetlands. The delta, with its marshes and sloughs, as well as large, open agricultural fields, is very important for migratory waterfowl and other birds, and a wildlife recreation area operated by the Washington State Department of Wildlife is located on Fir Island.

The Skagit River divides into two distributaries just below the town of Mount Vernon; the North and South Forks. Much of the river, below Sedro Woolley, has been extensively channelized, leveed and armored with riprap. The extensive streambank modifications have reduced the fish and wildlife support functions of the river and nearby riparian areas. The remaining habitat areas have become increasingly more important as they become more scarce. The river itself is a vital transportation route and spawning area for anadromous fish, such as chinook, coho, chum and pink salmon, steelhead and other trout species.

Agriculture, urbanization, channel modification and forest practices have significantly changed the Lower Skagit valley, as well as the upper watershed.

b. Fish. All five species of salmon use the Skagit River system; spring and summer/fall chinook (Oncorhynchus tshawytscha), coho (O. kisutch), pink (O. gorbuscha), chum (O. keta) and sockeye (O. nerka). Steelhead trout (O. mykiss), cutthroat trout (O. clarkii), Dolly Varden char (Salvelinus malma), bull trout (S. confluentus) and white sturgeon (Acipenser transmontanus) are also present. Most of these populations are maintained by natural production, however, hatchery production augments the chinook, coho and steelhead runs (see Table 2 for additional information).

TABLE 2
Selected Anadromous Fish Species in the
Skagit River Basin

Fish Species	Production[1]	Spawning Period	Juvenile Outmigration
Spring Chinook	5,300	July - September	March - July
Summer/Fall Chinook	49,800	September	March - June
Coho	149,900	December	March - June
Pink[2]	1,350,000	September-October	March - May
Chum, even year odd year	258,900 68,000	December	March - May
Sockeye	not available	September	N.A.
Steelhead, summer winter	16,800[3]	February March - June	April - May

[1] Production includes total catch and escapement from recent year catches, generally mid-1980's to 1990. From U.S. Fish & Wildlife Planning Aid Letter (see Appendix 5).
[2] Odd-year only runs.
[3] Includes hatchery and natural production for both runs.

Chinook salmon enter the system as two discrete races, the spring and summer/fall runs. The spring chinook enter the system in May or June, spawning from July to early September in the upper Cascade River, the upper Sauk River and the tributaries of the Suiattle River. The juveniles rear in freshwater for a few months and outmigrate from March to July. The summer/fall chinook enter the system from late June to early August, spawning in September in the mainstem and the major tributaries. The juveniles outmigrate in their first spring from late March to June. Both runs are cultured at the Clark Creek hatchery near Marblemount with outmigration usually coinciding with the natural runs. The 1992 Salmon and Steelhead Stock Inventory has identified the Lower Skagit and Lower Sauk chinook stocks as being depressed. This categorization indicates that production is below expected levels, but where permanent damage to the stock is unlikely.

Coho salmon enter the system from late August to September, spawning in December in all accessible tributaries. The juveniles rear in freshwater for a year and outmigrate in their second year from March to June. The natural run of coho has been significantly reduced over the last few years. Coho are cultured at both state and tribal hatcheries. The 1992 Salmon and Steelhead Stock

Inventory has identified the Skagit coho stocks as being depressed. This categorization indicates that production is below expected levels, but where permanent damage to the stock is unlikely.

Pink salmon enter the system in odd-numbered years only from August to October. Spawning occurs from September to late October in the mainstem above Lyman, the Sauk River, Cascade River and other major tributaries (except the Baker River). The juveniles are smolts at emergence and immediately outmigrate from March to May.

Chum salmon enter the system from October to late December, spawning in December in the mainstem, side channels and sloughs upstream of Rockport and the Sauk and Cascade Rivers. The juveniles outmigrate from March through May.

Sockeye salmon have been severely reduced in numbers, possibly due to dams on the Baker River. They enter the system from July through August and spawn on specially constructed beaches in the Baker River system. Several agencies are trying to restore the sockeye run in the Skagit. The 1992 Salmon and Steelhead Stock Inventory has identified this stock as being a critical stock which has declined to a point where it is in jeopardy of significant loss of within-stock diversity or extinction.

Steelhead return in summer and winter runs, from both natural and hatchery production. The summer run enters from May to October and do not spawn until February to March in the upper headwaters and tributaries. The juveniles rear in freshwater for two or three years before outmigrating from April to late May. The winter steelhead enter the system from January to March, spawning from March to June in the mainstem and most tributaries. Hatchery winter run steelhead enter from December to February, spawning from January to March near the hatchery facilities.

Searun cutthroat trout and Dolly Varden/bull trout char run over much of the year in the Skagit. Spawning peaks for the cutthroat in February and March. Spawning peaks for the Dolly Varden from September through November. The juveniles rear in freshwater for two or three years before outmigrating in the spring.

Most of the anadromous salmon and trout species outmigrate during the period from March through June. The sloughs and side channels provide rearing habitat for juvenile chinook and coho. Spawned out steelhead and cutthroat go downstream from March to June.

White sturgeon are also present but sparsely distributed. Several resident fish species occur in the basin including: resident rainbow and cutthroat trout, resident Dolly Varden and bull trout, whitefish, sculpins, large suckers, peamouth and dace.

The Samish River also has runs of chinook (hatchery), coho and chum salmon. Small steelhead and cutthroat runs also occur in the Samish River. The 1992 Salmon and Steel Stock Inventory has identified the Samish winter steelhead stocks as being depressed. This categorization indicates that production is below expected levels, but where permanent damage to the stock is unlikely.

c. Wildlife. The Skagit River basin is rich in wildlife resources with the greatest diversity in the more wooded areas east and north of Burlington. The project area lies in predominantly urban and agricultural areas around Burlington and Mount Vernon. Deciduous forest areas exist near the river and scattered between Mount Vernon and Sedro Woolley. The delta area below the fork is critical habitat for numerous species of migratory birds.

Wildlife species include blacktail deer, beaver, mink, muskrat, raccoon, river otters, coyotes, foxes, rabbits and smaller rodents. Numerous bird species are present seasonally or as residents. Bald eagles, peregrine falcons, red-tailed hawks, northern harriers, kestrels, ospreys, great horned owls, and barn owls are common raptors in the area. The wintering concentrations of bald eagles and other migratory species are quite high. Numerous passerine species are also present.

The marshes around the delta area support a rich variety of invertebrates, small fish, amphibians and reptiles that support the blue heron, green-backed heron and other wading birds. Trumpeter and tundra swans, Canada geese, snow geese, mallards, widgeons, teal and other ducks commonly migrate through the area utilizing both the marshes and agricultural fields. The common merganser, ouzel, and belted kingfisher are residents. Ruffed grouse and ring-necked pheasant are common in the forested and shrubby areas.

The upper basin contains the most diversity of wildlife because of its large area and the extensive areas of protected public land. The typical mature overstory in nonprotected areas consists of second growth Douglas fir, western red cedar and western hemlock. In clearcut areas, intermediate species such as vine maple, Pacific dogwood, willow and red alder are common. Wildlife species in the upper basin are skunk, red and gray fox, black tailed deer, black bear, elk and bobcat. Many of the raptor and passerine bird species from the lower basin are common in the upper basin as well.

d. Threatened and Endangered Species. Several listed species occur in the Skagit River basin including: bald eagle, peregrine falcon, bull trout, red-legged frog, spotted frog, and California floater. There may be a listing of one or more salmon species in the Skagit River due to the loss of habitat and overfishing problems.

2.1.6 Water Quality.

Water quality in the upper river (above Marblemount) is excellent. The lower river is somewhat degraded from logging, agriculture and urban runoff. However, the Skagit River is still rated as Class A by the Washington Department of Ecology.

2.1.7 Navigation

Navigation on the Skagit River is confined to recreational navigation throughout a great portion of the stream to Marblemount. Deeper water is in the North Fork's tributary, but access to and from saltwater is feasible only during high tide stages. In 1965, the Corps of Engineers completed a report that concluded that improvement of the Skagit River for navigation was not economically feasible at that time because transportation cost savings in waterborne commerce would be too small to justify the expenditure necessary for developing a project. Also, navigational improvements could have severe environmental effects.

2.1.8 Transportation Services.

Skagit County is served by most major forms of transportation (see Plate 1). Burlington Northern Railroad provides rail access to the area. The county is readily accessible by vehicle from I-5, which extends north-south, and SR 20, which runs eastward from Discovery Bay, through Port Townsend and Oak Harbor, up the Skagit River Valley, and across the Cascade Mountains into eastern Washington. Deep-draft shipping terminal facilities serve petroleum refineries at Anacortes, and ferry service from Anacortes links the mainland with the San Juan Islands and Sidney, B.C. near Victoria, B.C. There is no major scheduled commercial airline service in the area, but local airfields are operated for charter and regional service.

2.1.9 Recreation.

The Skagit basin currently offers excellent recreational opportunities, especially in the upper basin. In publicly owned areas there are numerous opportunities for hiking, bird watching, photography, recreational boating and other activities. The Sauk River is designated as a Wild and Scenic River (administered by the U.S. Forest Service) as is the Skagit River above Sedro Woolley. The lower basin and delta are renowned for bird watching opportunities, especially when bald eagles, snow geese and other migratory birds are present. The level county roads throughout the lower basin are heavily used by recreational cyclists, particularly during the spring flowering of the commercial bulb fields. The annual Tulip Festival in Mount Vernon is a popular tourist event drawing visitors from throughout the Seattle-Bellingham corridor.

2.2 Basin Flood Characteristics.

2.2.1 Basin Description. A reconnaissance level hydrology analysis was performed for the lower portion of the Skagit River downstream of the USGS stream gage near Concrete to Skagit Bay. The last major hydrologic study was performed in 1979 for the Skagit River, Washington, General Design Memorandum; Levee Improvements. This reconnaissance level investigation updates the 1979 study data for input to unsteady state hydraulic modeling of the lower Skagit River from Sedro Woolley to the mouth. Overall, the addition of new streamflow data through 1990 produced a slight rise of about 5 percent in regulated discharge frequency estimates at Concrete and an average decrease of about 5 percent in the Mount Vernon regulated discharge frequency estimates.

The Skagit River originates in a network of narrow, precipitous mountain canyons in Canada and flows west and south into the United States where it continues 135 miles to Skagit Bay. The stream falls rapidly from its source near 8,000 foot elevation to an elevation of 1,600 feet at the U.S. Canadian border before flowing through three Seattle City Light owned dams. Below the dams, the main river flows in a valley 1 to 3 miles wide from Rockport to Concrete (river mile 54.1) and then to Sedro Woolley (river mile 22.3). In this section, the valley walls are steeply-rising timbered hills.

Below Sedro Woolley, the valley descends to nearly sea level and widens to a flat, fertile outwash plain that joins the Samish valley to the north and then extends west through Mount Vernon to LaConner and south to the Stillaguamish River. Between Mount Vernon and Sedro Woolley, a large area is being used as storage, primarily in the Nookachamps creek basin along the left overbank of the Skagit River. For very high river flows at Mount Vernon (over 146,000 cfs) a portion of the Skagit River in this reach can overflow along the right bank and escape out of the system through Burlington to the Samish River and Samish Bay. The Skagit River continues through a broad outwash plain in the lower reach nearest the river mouth and divides between two principal tributaries, the North Fork and the South Fork, which are 7.3 and 8.1 miles long, respectively. About 60 percent of the discharge is carried by the North Fork and the remainder is carried by the South Fork during the usual range of river discharges.

The Sauk River (drainage area 732 square miles) is the largest tributary in the Skagit River basin, and enters the Skagit River at river mile 67.2. The Baker River (drainage area 297 square miles), the second largest tributary, enters the Skagit River at river mile

56.5.

2.2.2 Existing Projects. Five dams have been constructed in the Skagit River Basin for generation of hydroelectric power. (See Plate 1). Two of these dams (Ross and Upper Baker) also provide considerable flood control storage. At Ross Dam, induced non-surcharged storage up to a maximum of approximately 120,000 acre-feet (elevation 1602.5 feet) may be utilized to control critical and major floods. Flood control storage at Upper Baker Dam has been increased from 16,000 (lost valley storage replacement) to 74,000 A.F. (elevation 724.0) in 1977 in accordance with the Secretary of the Army and the Chief Engineers in House Document No. 95-149.

Seattle City Light owns three dams on the mainstem Skagit River (Ross, Doable, and Gorge Dams). Ross Dam (river mile 105), completed in 1949 has a total nameplate capacity of 360,000 kilowatts (kW). Diablo Dam was completed in 1930 at a point about 4 river miles below the present Ross site, with a total nameplate capacity of 122,400 kW. Gorge Dam, about 4 miles down river from Diablo Dam, was completed in 1961 and has a nameplate capacity of 137,700 kW.

Two dams on the Baker River are owned by Puget Sound Power and Light Company. The first dam (Lower Baker), completed in 1927 at a site near the mouth, has a nameplate rating of 64,000 kW. The second dam at Baker Lake (Upper Baker), 8 miles upstream of Lower Baker Dam, was completed in 1959 with a nameplate rating of 94,400 kW.

During the November through March flood season, flood control regulation at both Ross and Upper Baker dams commences when the natural flow in the Skagit River near Concrete is forecast to reach or exceed 90,000 cfs within the next 8 hours. The Corps of Engineers directs operation of Ross and Baker projects during major floods. Project releases are selected with reference to formal operating plans which consider flows at Concrete, reservoir pool elevations, and observed and forecast reservoir inflows and local/tributary runoff.

2.2.3 Climatology. Mean monthly temperatures in the Skagit River basin vary from about 40.1 degrees F at Mt. Baker Lodge to 50.7 degrees F at Concrete. Normal monthly temperatures vary in January from 26.9 degrees F at Mt. Baker Lodge to 37.7 degrees F at

Sedro Woolley and in August from 56.7 degrees F at Mt. Baker Lodge to 64.7 degrees F at Diablo Dam. Temperature extremes recorded in this basin are 109 degrees F at Newhalem and -14 degrees F at the Darrington Ranger Station.

Mean annual precipitation varies from 40 inches or less near the mouth of the Skagit River and in the portion of the basin in Canada which lies in a topographic rain shadow, to an average of 180 inches or more at the higher elevations of the Cascade Range in the southern end of the basin and over the higher slopes of Mt. Baker. Mean monthly precipitation at stations in or near the basin ranges from 0.82 inch in July at Anacortes to 16.99 inches in December at Mt. Baker Lodge. The maximum recorded precipitation for 1 month was 41.95 inches at Silverton in January 1953. Storm studies indicate that 5 to 6 inches of rainfall in a 24-hour period have occurred over much of the basin.

Snowfall in the Skagit River Basin is dependent upon elevation and proximity to the moisture supply of the ocean. The mean annual snowfall varies from 5.6 inches at Anacortes to 525.3 inches at Mt. Baker Lodge with an annual maximum of 699 inches recorded at the latter. Snow surveys have been made within the Skagit Basin since

1943. In 1958, an updated network of snow course survey sites was established in the Baker River Basin.

2.2.4 Storm Characteristics. In the winter, the Skagit River basin lies directly in the path of many low pressure weather systems from the Pacific Ocean. Characteristically, these storms are typically about 24 hours in duration, with moderate and fairly constant precipitation seldom exceeding one inch per hour. Not uncommon are two or more storms in rapid succession, sometimes less than 24 hours apart. As storms pass over the mountains, a combination of frontal and orographic effects can cause heavy and almost continuous precipitation.

2.2.5 Streamflow Records. Four USGS continuous recording stations were examined in this study. These stations are the Sauk River near Sauk (#12189500, river mile 5.4), which has continuous record that extends back to July 1928, the Skagit River near Concrete (#12194000) with record that extends back to September 1924, the Skagit River near Sedro Woolley (#12199000) with record available between 1908 to 1928 and February 1975 to June 1980; and the USGS gage at Mount Vernon (#12205000, river mile 15.7) with record that extends back to October 1940.

Historic flood peaks are published by the USGS for year 1815, 1856, 1898, 1910, 1918 and 1922 for Concrete. The maximum historic discharge was 500,000 cfs and occurred in 1815 at Concrete. Table 3 lists flood peaks for the five highest recorded regulated flood peaks at Concrete and Mount Vernon.

TABLE 3

Highest Recorded Peak Discharges (Regulated)

SKAGIT RIVER NR. CONCRETE (USGS #1294000)		SKAGIT RIVER NR. MOUNT VERNON (USGS #12205000)	
Date	Flow, cfs	Date	Flow, cfs
10 Nov 90	149,000	25 Nov 90	152,000[4]
26 Dec 80	148,700	10 Nov 90	142,000[5]
25 Nov 90	146,000	4 Dec 75	130,000
18 Dec 79	135,800	27 Dec 80	114,000
04 Dec 75	122,000	12 Dec 79	112,000

2.2.6 Flood Characteristics. Mean annual flows of the Skagit River at Mount Vernon range from about 10,000 to 20,000 cfs (cubic feet per second). Discharge is normally lowest from August through October. During April or May, the discharge increases due to the melting snowpack and normally crests in early June, but are lower

[4] The flood fighting activity increased discharge slightly. This must be subtracted when establishing the recurrence interval using regulated flood frequency data in this report.

[5] Peak at Mount Vernon reflects valley storage at Nookachamps.

than winter flows.

The spring snowmelt is characterized by its relatively slow rise and long duration. While this high water occurs annually, it seldom reaches a damaging stage. During the annual spring or early summer high water, reservoirs are filling, and as a result, the spring peak discharges are frequently reduced downstream of reservoirs.

Winter rain type floods usually occur in November or December, but may occur as early as October or as late as February. All major floods of record on the Skagit River have occurred during this period. Winter flows are characterized by frequent sharp rises resulting from concentrated 2 to 5-day storms or series of storms. Floods with high peaks and low volume are attenuated by the overbank storage primarily in the Nookachamps basin (e.g. December 1977) while higher volume floods show a tendency to increase in discharge (e.g. December 1975 and 25 November 1990) primarily due to the filling of overbank storage areas.

The sequence which usually produces these events starts with antecedent precipitation from a series of storms which serves to build up ground water reserves and reduce infiltration rates. Frequently, a snowpack is then formed over most of the basin near the end of these rains which reduces evaporation and maintains the saturated condition. A subsequent heavy rainfall accompanied by warm winds and melting snowpack completes the sequence which produces major winter floods. Occasionally, floods follow in very close succession with sufficient rainfall to produce long duration floods which are generally the most threatening and damaging to life and property. Two or more major floods may be experienced within a period of a week or two as a series of storms move across the basin from the west. This can pose significant problems in evacuating reservoir flood storage as was nearly the case in November 1990.

Since 1925, flood peaks have been reduced in varying amounts by incidental regulation for hydropower production and to a major extent due to formal flood control operations at Ross and Upper Baker dams. However, the flood control potential of the two projects is diminished by the large, uncontrolled tributary area downstream of the dams, which represents 62 percent of the total

Skagit River drainage basin.

2.2.7 Flood Warnings and Runoff Timing. The National Weather Service provides flood warnings for the Skagit River stations at Concrete and Mount Vernon. The National Weather Service River Forecast Center in Portland uses the SSARR model for flood forecasting, with travel times from Ross Dam to Mount Vernon built into it. However, a local Flood Warning System might be very useful for this river system. There are numerous gages, adequate travel time between gages, and enough lag time between precipitation and peak flows to enable considerable advance warning of potential flood conditions especially in the Mount Vernon area. Typically, travel time from many of the tributary streams below Ross Dam to Concrete is as long as 8 hours. The travel time from Concrete to Mount Vernon during a flood episode is approximately 10-14 hours. Previous research by the Corps of Engineers, Seattle District Hydrology Section has indicated that for high flows with nominal volume the apparent travel time between Concrete and Mount Vernon is actually longer due to the effects of overbank storage mainly in the Nookachamps creek basin. This storage tends to depress the flow, particularly on the rising limb of the hydrograph. The effect is diminished for large volume floods.

The peak precipitation in the Upper Skagit River Basin will generally occur 18 to 24 hours prior to the peak flow at Mount Vernon.

2.2.8 Tidal Flood Characteristics. Tidal conditions influence the flood profiles for the study reach between the mouths of the North and South Forks and Sedro Woolley. Mean High Water (MHHW) at Skagit Bay is approximately 5 feet NGVD. It has been shown from studies performed in 1980 that MHHW +1 foot approximates the combined coincidental tidal and meteorological effects of a flood in recurrence range from 10 to 200 years at the mouth of a river. The assumption was made that a similar tidal condition would exist during any future floods, so that a constant tide elevation of 6 feet NGVD (MHHW +1 foot) was used for all hypothetical flood simulations in this reconnaissance study to ensure the maximum impact of tidal and river conditions. Actual tidal elevations were used in hydraulic model verification runs of observed events.

2.2.9 Flood Frequencies. The intent of the frequency analysis was to evaluate if there has been a change in the Skagit at Concrete and Mount Vernon frequency curves since the last study which was completed in 1979. Five floods with peaks greater than 100,000 cfs at Concrete (1980, 1981, 1984 and 1990 (twice)), were examined and deregulated by approximation to eliminate the effects of Ross and Upper Baker flood regulation but not incidental regulation.

Natural peak flood discharges from the Sauk River, the largest tributary to the Skagit River, were used as an indicator of flood frequency curve shifts. Peak flood discharges on the Sauk River near Sauk, WA were compared to the 1979 study. A small increase in flood peaks was noted since 1979 which is consistent with the computed change at Concrete but not at Mount Vernon.

It was found that with the addition of new flood peak data through 1990 the regulated and unregulated discharge frequency increased approximately 3 to 6 percent, respectively at Concrete. Concrete flows were transferred to Sedro Woolley, the upstream boundary for hydraulic unsteady flow modeling, by methods discussed later under Flood Hydrographs.

Local inflow between Concrete and Mount Vernon does not have a major influence on Skagit River flood peaks and was not re-evaluated for this reconnaissance study.

The regulated and unregulated frequency curves for Mount Vernon reflect the loss of floodwater to the Samish River and no flood fighting activity. Regulated flood peaks at Mount Vernon for all years since 1979 were also examined and compared with data prior to 1979. The regulated frequency curve for Mount Vernon was found to decrease about 3 percent above 150,000 cfs since 1979, and about 8 percent below 150,000 cfs which was not consistent with upstream results. The difference could be attributable to storage effects between Concrete and Mount Vernon that may not have been fully reflected in the previous unsteady flow studies. The unregulated frequency curve for Mount Vernon was assumed to have a similar shift. Feasibility studies will investigate in more detail the amount of water that escapes to the Samish River at high discharges.

Table 4 (Discharge-Frequency Data) shows current reconnaissance level values for Concrete, Sedro Woolley, and Mount Vernon regulated flows. It should be noted that the Discharge-Frequency curve for Mount Vernon is only valid for the Mount Vernon USGS station. Any point upstream or downstream from the USGS station will not have the same discharge.

TABLE 4

Discharge-Frequency Data (Regulated)

	SKAGIT RIVER NR. CONCRETE (USGS #12194000)	SKAGIT RIVER NR. SEDRO WOOLLEY (USGS #12199000)	SKAGIT RIVER NR. MOUNT VERNON (USGS #12205000)
	Flow, cfs	Flow, cfs	Flow, cfs
10-year	129,000	137,000	114,000
25-year	167,000	174,000	146,000
50-year	197,000	207,000	158,000
100-year	235,000	236,000	180,000

The recurrence interval of the 24 November 1990 flood at Mount Vernon based on the above flood frequency data (and considering flood fighting activity) is about 35 years which is within the range of previous Corps estimates for this event. Reference Flood Summary Report; Nooksack, Skagit, and Snohomish River Basins, November 1990 events, 18 July 1991 which showed a preliminary estimate of 25 years immediately after the flood using provisional data and a subsequent estimate of 40-years with more refined data.

Finally, verification of flood routing against the regulated flood frequency curve at Mount Vernon was performed. Whenever applicable, the criteria established in the United States Water Resources Council Bulletin 17B was followed, including the expected probability adjustment in the revised flood frequency curves (Sauk River).

2.2.10 Interior Runoff. Existing condition interior runoff and ponding areas were examined in the 1979 study to determine residual damages and to demonstrate that flooding from interior runoff would not pose a hazard greater than flooding by the river or tides. No new significant changes in interior conditions have occurred since the 1979 study, however, several alternative flood control schemes involving a change in interior runoff condition were examined. Several pumps and additional drainage structures were included in the reconnaissance cost estimate. Interior runoff will be re-evaluated in detail during the Feasibility Study to determine if the proposed drainage structures are necessary or if more are required. Additional studies will also be conducted to determine the flow paths of flood waters once they have gone over the overtopping levees and to see if existing drainage structures would be adequate to handle those flood waters.

2.2.11 Flood Hydrographs. Observed data for floods of December 1975 and November 1990 were prepared for hydraulic unsteady flow model investigations. The 1975 flood was the most recent large flood that could be thoroughly modeled from Sedro Woolley to Mount Vernon since it represents essentially a levee-contained condition where as levees at Fir Island broke during 1990 floods resulting in large flow volumes and rates which would not be simulated in the existing flow needed with the existing available data. However for calibration purposes, the two 1990 floods in November were examined up to the time the levees were breached. Hypothetical 10-, 50-, and 100-year hydrographs to test the failure of levees and alternatives evaluation were also developed. The patterns for existing regulated conditions of the 50 and 100 year flood were obtained from previous SSARR Model runs for regulated conditions in the Skagit River Basin. Flood volumes were re-evaluated from previously developed hydrographs. Regressions from 1, 3, and 5 day mean discharges vs. peak discharges were examined with new flood data to determine if there had been changes in the flood volume relationships. No significant change from these previously derived regressions were noted for the Skagit at Concrete. The hydrographs for Concrete were correlated to Sedro Woolley, the upstream boundary for the unsteady model, using the regression plot of peaks on the Skagit at Concrete vs. Sedro Woolley. Existing condition regulated hydrographs with peaks of 25, 50, 75, 100, 125, 150, 175, and 225 thousand cfs at Sedro Woolley were also developed. All hydrographs were adjusted to reflect changes in the final frequency curves.

2.2.12 Reservoir Regulation. The current authorized method of flood regulation for Ross Dam maximizes flood reduction benefits, and calls for releasing no more than inflow from storage after the peak until the discharge at Concrete (the primary control point) recedes to below 90,000 cfs (32.2 feet). This plan does slightly decrease the time floodflows are above damage levels over that provided by Upper Baker regulation (discussed later). There are minor risks associated with the currently authorized method including the potential for an "induced" secondary flood peak at Concrete (a later increase in flows above flood stage). This can occur during evacuation particularly at Ross Dam due to the long travel time to Concrete (about 8 hours) and the limited abilities to exactly forecast local runoff. Evacuation of storage from Ross Dam is weighed against the volume of storage to be recovered, the future need for flood storage, and secondarily against what value it has in power production. Ross Dam provides incidental storage regulation during nearly all minor floods, because the pool elevation at the onset of these events is almost always below 1,590 feet. The current authorized method of flood regulation for Upper Baker Dam requires the release of stored flood water immediately after it is assured that Concrete has peaked. This operation maximizes flood storage but allows floodflows to remain above major damage longer than the Ross Dam regulation plan (about 6 hours longer). Because Upper Baker Dam is much closer to Concrete than Ross Dam, there is more certainty as to how releases at Upper Baker will effect downstream flood stages.

2.2.13 Upstream Storage Effects. The updated flood frequency curves show that the break between regulated and unregulated (dams in place but without formal control storage) is at approximately

70,000 cfs for Mount Vernon (based on the updated flood frequency curve plot) and about 90,000 cfs for Concrete, even though regulation of individual events usually begins at between 55 to 60,000 cfs at Concrete. The effects of Ross and Upper Baker in reducing the flood flows is significant. At the 100-, 25-, and 10-year frequency levels, the unregulated flows at Mount Vernon are reduced by about 35,000, 15,000 and 25,000 cfs, respectively (less reduction at the 25-year level due to the theoretical onset of levee failures.

2.2.14 <u>Regulation Alternatives</u>. Several possible regulation alternatives associated with how upstream reservoirs might be more effectively regulated during flood events to benefit the present state of development will be addressed in feasibility studies (these might also effect the base case analysis). The pressure to prevent such problems as levee failures due to saturation by reducing dam outflows particularly during recession can result at times in more water being stored in the reservoirs than was originally anticipated. For example, even though drawdown below the existing flood control rule curve at Ross and Baker Dams occurred prior to the 10 November 1990 flood (about 6 feet at Ross and 7 feet at Upper Baker), the reservoirs nearly filled during recession partly because of reduced releases during recession to limit levee saturation. This operation for the November 1990 flood was successful (although incidental in that it cannot be counted on from year to year) only because the Quantitative Precipitation Forecast (QPF) indicating future storm conditions was low, and less rain fell than was anticipated. However, this operation can have the effect of reducing the average overall level of protection if implemented without increasing the amount of flood storage space in the reservoirs. If the reservoirs had not been initially low prior to the 10 November flood, storage would have been depleted and downstream releases would have been greater, resulting in potentially more extensive flood damage. The potential for changing the flood control operation for Upper Baker is much less likely than for Ross Dam due to language differences in the FERC (Federal Energy Regulatory Commission) licenses.

Several alternate regulation plans have been proposed for either increasing the level of flood protection and/or allowing longer storage time at the dams to assist in limiting levee saturation and the duration various damaged elements are subjected to flooding. One of these plans for Ross Dam would increase the level of flood protection by releasing water in storage after the river flow has crested and begins to recede (similar to Baker Dam). This measure, along with monitoring reservoir pool elevations and discharge readings downstream especially during the onset of flood season, could make possible more effective reservoir regulation and use of available storage for a larger range of events. However, this operation is only effective as long as the levees do not fail from saturation or overtopping and other downstream structures are not jeopardized.

A second regulation plan for Ross Dam would involve a request for additional flood control storage in Ross reservoir to allow longer retention of stored flood waters without diminishing the level of protection (this would also involve an evaluation of the early fall drawdown requirements). There is a provision in the FERC license that might be applicable which may allow for additional storage space if downstream development or other circumstances warrant the need and can be justified. It is far from certain whether this provision could be applied to the conditions of this study. A third plan might be to reduce the allowable powerhouse release from Upper Baker and Ross Dams during a flood (about 5,000 cfs maximum from each project on a daily average basis). This would involve a need for additional storage spaces and possible lost power revenue.

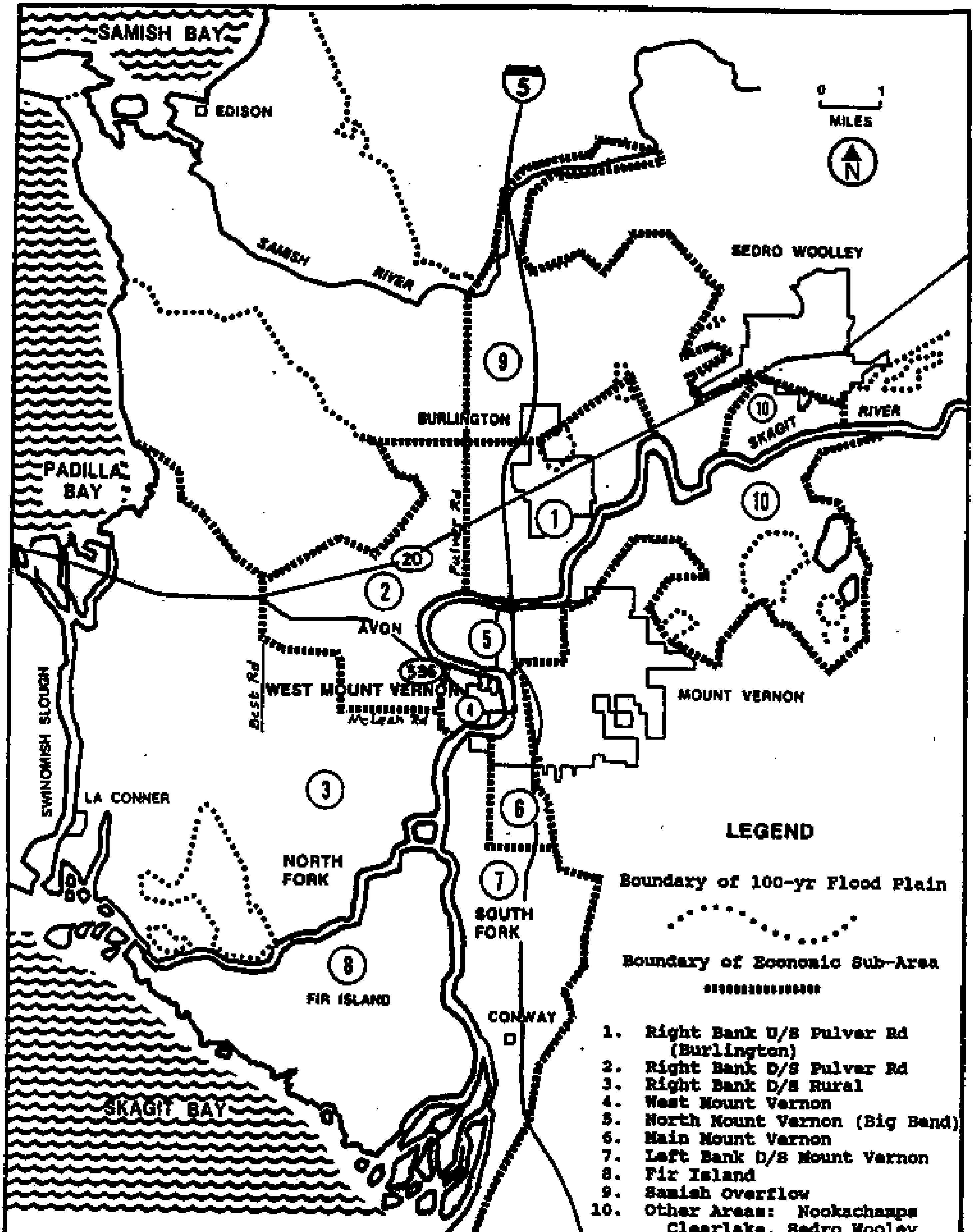
The bottom line is that there is a need to examine these issues in more detail, and this can and should be addressed in a feasibility study. Re-authorization of Upper Baker flood control by Congress would be required to implement a change of flood control operation at this project, and possibly also a change in the FERC license. Ross Dam operation is currently governed only by its FERC license.

2.2.15 Flood Damages.

a. Flood Damages Under Existing Conditions. The area considered for flood damage reduction in this reconnaissance study begins downstream of Sedro Woolley, continues south through the cities of Burlington and Mount Vernon and on to Skagit Bay. Other than the two cities located in the lower basin, land use is devoted primarily to agricultural and dairy production with a high degree of rural/suburban type development.

During November 1990 the basin experienced two significant flood events. During the first flood, November 9-12, (estimated at a 25 year event), a levee failure occurred along the North Fork of the Skagit inundating the Fir Island area in water depths up to eight feet, and causing substantial damage in other areas throughout the basin. Two weeks later the basin experienced a second flood, estimated at a 35 year event. Fir Island again was the hardest area hit, but areas around Burlington, Sedro-Woolley, Mount Vernon, Concrete, Hamilton, and Lyman reported significant damages. Basin wide, damages were estimated to be $39,800,000 This figure could have been substantially higher had it not been for successful flood fighting in the areas of Burlington, Mount Vernon and West Mount Vernon, or if a second levee failure had occurred.

b. Average Annual Damages. Average annual damages in the Skagit River basin have been quantified for ten different economic sub-areas within the basin (see Figure 1). Important information used in deriving expected annual damages includes the discharge-damage relationships established for the 1979 Skagit River General Design Memorandum Study (GDM), a 1992 geotechnical evaluation of the structural adequacy of existing levees to determine zero damage (probable failure and non-failure) elevations within each sub-area (see Appendix 2), hydraulic evaluation of the discharge associated with the Probably Failure Point (PFP) and Probable Non-Failure Point (PNP) elevations, and a slightly revised frequency-discharge curve from that used in the 1979 GDM evaluation. This information was compiled, price updated, adjusted for growth and used in the Corps of Engineers Expected Annual Damage (EAD) program to derive expected annual damage for each sub-area. Expected annual damages within the study area are estimated to be $9,957,000.



Skagit River, Washington — ECONOMIC ANALYSIS SUB-AREAS — Figure 1

Table 5 lists assessed property values by diking district in the study area. For each diking district a corresponding economic sub-area is also identified. The diking districts boundaries and economic sub-areas correspond roughly, and should only be used to give the reader a general idea of the areas. The total assessed value of diking district in the study area is over $935 million.

Table 6 lists expected damages for various flood events broken down by sub-area. Damages for a twenty-five year event are estimated to be nearly $94 million, for a fifty year event $172 million, $257 million for a 100 year flood, and close to $400 million for the standard project flood event.

TABLE 5

DIKING DISTRICT

1992 ASSESSED VALUE

Dike District[6]	Corresponding Economic Sub-Area[7]	Assessed Value
Dike District #1	(3) Right Bank D/S Rural	$100,468,300
	(4) West Mount Vernon	
Dike District #3	(6) Main Mount Vernon	$160,621,325
	(7) Left Bank D/S Rural	
Dike District #12	(1) Right Bank U/S Pulver	$518,493,334
	(2) Right Bank D/S Pulver	
Dike District #17	(5) North Mount Vernon	$121,697,830
Dike District #22	(8) Fir Island	$ 31,649,700
Dike District #20	(10) Nookachamps	$ 2,172,600
	Total Assessed Value	$935,103,089

[6] Diking District #9 assessed value unavailable.
[7] This is meant to be a general or rough comparison.

TABLE 6
SKAGIT BA[illegible]
EXPECTED DAMAGES FOR VARIOUS FLOOD EVENTS
OCT. 1993 PRICES AND CONDITIONS

ECONOMIC SUB-AREA	EXPECTED DAMAGES (IN $1,000) 25 YEAR	50 YEAR	100 YEAR	SPF
1. RIGHT BANK U/S PULVER ROAD	$0	$15,700	$31,000	$100,300
2. RIGHT BANK D/S PULVER ROAD	$2,100	$14,100	$26,200	$33,900
3. RIGHT BANK D/S RURAL	$1,700	$12,400	$21,600	$29,400
4. WEST MT. VERNON	$8,000	$14,600	$24,200	$38,500
5. BIG BEND (N. MT VERNON 8/	$8,700	$20,500	$37,400	$46,300
6. MAIN MT. VERNON	$45,400	$54,100	$66,500	$70,800
7. LEFT BANK D/S MT. VERNON	$12,400	$14,900	$17,800	$24,800
8. FIR ISLAND 9/	$14,500	$16,800	$18,800	$23,200
9. SAMISH OVERFLOW	$0	$4,000	$7,400	$13,300
10. OTHER AREAS NOOKACHAMPS, CLEARLAKE SEDRO WOOLEY	$847	$5,100	$6,100	$8,500
TOTAL	$93,647	$172,200	$257,000	$389,000

8/ Damages for the 25 year flood event in sub-areas 5 & 8 assume a levee failure at the probable non-failure point.
9/ Expected damages in the other subareas for the 25 year event reflect non-failure and failure points occuring at the same frequency.

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Within each area, expected annual damages have been broken into seven categories including residential structures, residential contents, commercial and industrial establishments, public expenditures, emergency aid, agricultural land, crops & improvements, as well as a miscellaneous category. The following briefly describes each area and lists the expected annual damages. Table 7 summarizes the existing damage for the study area.

(1) Right Bank Urban Upstream of Pulver Road. This reach includes the city of Burlington (1992 pop. of 4690) and the surrounding suburban area along the State Route 20 and Interstate 5 corridors. Over the past 15 years this area has experienced substantial growth, gaining several large shopping malls and outlet centers and suburban residential development. The zero damage discharge for this reach has been estimated to be 145,000 cfs (all discharges referenced are at the Mt. Vernon gage unless otherwise noted) which corresponds to approximately a 25 year event. The probable failure point (PFP) and probable non-failure point (PNP) were estimated to be at the same elevation because the failure point is when the flood waters overtop Highway 20 and enter this area. Flooding begins in an area just upstream of this reach when the levee is outflanked on the upstream end, and flood waters enter Gages Slough. This reach is a portion of dike district #12. Average annual damages are estimated to be just over $1 million and are broken down as follows:

TABLE 7

EXISTING CONDITION

BY ECONOMIC SUB-AREA AVERAGE ANNUAL DAMAGES

(OCTOBER 1993 PRICES AND CONDITIONS)

Economic Sub-Area	Existing Average Annual Damages
1. Right Bank U/S Pulver Road (including Burlington)	$1,066,000
2. Right Bank D/S Pulver Road	$ 636,000
3. Right Bank D/S Rural	$ 539,000
4. West Mount Vernon	$ 787,000
5. Big Bend (North Mount Vernon)	$1,050,000
6. Main Mount Vernon	$3,525,000
7. Left Bank D/S Mount Vernon	$1,003,000
8. Fir Island	$ 812,000
9. Samish Overflow	$ 197,000
10. Other Areas Nookachamps, Clear Lake, Sedro Woolley	$ 342,000
Total	$9,957,000
Residential Structures	$346,000
Residential Contents	165,000
Commercial/Industrial	196,000
Public	73,000
Emergency Aid	155,000
Agriculture	14,000
Other	117,000
Total	$1,066,000

(2) Right Bank Downstream of Pulver Road. This economic sub-area covers the suburban and agricultural area southeast of Burlington. The area begins downstream of Pulver Road and continues south to McLean Road outside of West Mt. Vernon.

This reach also roughly lies within the boundaries of Diking District #12. The zero damage point was determined to be approximately 138,000 cfs, or about a twenty year event. The PNP and the PFP were estimated to be at the same elevation because these areas become inundated when the waters come over the low point in the levee where SR 536 crosses the levee. Flood waters first enter this area from West Mount Vernon (discussed below), however the sheet flow through this area at discharges ranging from 138,000 cfs to 143,000 cfs cause minimal damages. At approximately a twenty five year event, (146,000 cfs) levees along the North Fork of the Skagit or in West Mount Vernon are expected to fail causing a substantial amount of damage to sub-areas 2, 3, and 4. Expected annual damages for sub-area 2 are broken down below.

Residential Structures	$266,000
Residential Contents	110,000
Commercial/Industrial	65,000
Public	81,000
Emergency Aid	47,000
Agriculture	56,000
Other	11,000
Total	$636,000

(3) Right Bank Downstream Rural. This sub-area roughly corresponds to Dike Districts #1 (excluding West Mount Vernon) and #9. The area lies downstream of sub-area 2, is bordered on the west by Swinomish Slough, on the east and south by the North Fork

of the Skagit River. Land use is predominately agricultural, with a substantial amount of rural development. The zero damage point for this sub-area is assumed to be at the same point as that established for area 2 based on geotechnical observations, approximately a twenty year event, with major damage not occurring until 146,000 cfs or a twenty five year event. Flood waters from West Mount Vernon or along the North Fork would contribute to substantial damage once a discharge of 146,000 cfs is exceeded. Expected damages for this reach are $539,000 with over 50% of these damages accruing to agricultural lands and improvements.

Residential Structures	$81,000
Residential Contents	38,000
Commercial/Industrial	70,000
Public	10,000
Emergency Aid	51,000
Agricultural	285,000
Other	4,000
Total	$539,000

(4) West Mount Vernon. The area of West Mount Vernon is one of the three urban areas in the Skagit 100 year flood plain. Flooding which causes major damage in West Mount Vernon begins when a low spot in the roadway on SR 536 is overtopped. This occurs at a discharge of 117,000 cfs, or just over a ten year event. A small area outside (riverward) of the levee is inundated at approximately

100,000 cfs with resulting average annual damages in the area estimated at $20,000. (These damages are not included in the figures below.) Since there is no uncertainty in the levee/roadway structural reliability below this discharge, and there is a 100% chance that it will be overtopped with discharges exceeding 117,000 cfs, the PNP and PFP are at the same elevation. Likewise for any discharge less than 117,000 cfs there is a zero percent chance that this sub-area would experience any damages. Discharges between 117,000 cfs and approximately 146,000 cfs would be expected to cause relatively minor damages in this area. Once flows exceed a twenty five year event, the area would be expected to have significant damages due to levee failures. Expected annual damages total $787,000 and are broken out below.

Residential Structures	$234,000
Residential Contents	105,000
Commercial/Industrial	354,000
Public	40,000
Emergency Aid	43,000
Agriculture	3,000
Other	8,000
Total	$787,000

(5) North Mount Vernon. The area of North Mount Vernon, often referred to as the Big Bend area, is located on the left bank of the Skagit, northeast of the downtown Mount Vernon area. The sub-area is bounded on the north, west and south by the

Skagit River and on the east by high ground. This area corresponds to Dike District #17. The eastern portion of the diking district, along the I-5 corridor, is predominately commercial, with a high rate of development over the past ten years. The western portion, which is more rural, contains the Anacortes Water Treatment Plant. For this reach the PNP was determined to be a 20 year event (138,000 cfs) while the probable failure point has been estimated at a 25 year event (146,000 cfs) based on geotechnical observations. Average annual damages assuming the levee fails at the twenty year discharge are estimated to be $1,070,000. Expected annual damages assuming the levee does not fail until a twenty-five year event are $1,027,000. For simplicity, during the reconnaissance study phase, a simple average of the damages under each failure assumption was taken to establish existing condition average annual damages. This appears to be a reasonable approach considering the difference between the two damage figures is only $43,000. The average annual damages for the sub-area which will be used in the benefit evaluation are as follows.

Residential Structures	$127,000
Residential Contents	56,000
Commercial/Industrial	383,000
Public	111,000
Emergency Aid	321,000
Agriculture	41,000
Other	11,000
Total	$1,050,000

(6) Main Mount Vernon. A portion of the city of Mount Vernon (1992 population of 19,550) including the downtown area is located in this sub-area. The sub-area continues south along the I-5 corridor on the left bank of the Skagit until the split between the North and South Fork. This is the most highly developed area within the study area. The area is a part of Diking District #3. Flooding begins south of the West Mount Vernon bridge, when a parking revetment is overtopped. This occurs at approximately a ten year event, or a discharge of 117,000 cfs. The PNP and PFP occur at the same elevation because the city will flood when water comes over the existing revetment. Average annual damages under existing conditions are over $3.5 million, and are broken downs as follows.

Residential Structures	$1,238,000
Residential Contents	582,000
Commercial/Industrial	998,000
Public	99,000
Emergency Aid	550,000
Agriculture	6,000
Other	52,000
Total	$3,525,000

(7) Left Bank Downstream Mount Vernon. This sub-area, also a part of Diking District #3, begins south of Mount Vernon and

continues along the I-5 corridor through Conway and on to Skagit Bay. The reach is bordered on the west by the South Fork of the Skagit and on the east by high ground. Flooding in this area begins when the revetment in Mount Vernon is overtopped, which occurs at 117,000 cfs or just over a ten year event. Because of this, the PNP and PFP are identical. Land use in this area is a mixture of agricultural and rural/suburban development. The small town of Conway is also located in this sub area. Expected annual damages are broken down by category below.

Residential Structures	$212,000
Residential Contents	144,000
Commercial/Industrial	141,000
Public	198,000
Emergency Aid	46,000
Agricultural	238,000
Other	24,000
Total	$1,003,000

(8) Fir Island. This sub-area corresponds to Diking District #22. The area is bordered on the east by the South Fork, on the north by the North Fork of the Skagit River, and on the southwest by Skagit Bay. During the November 1990 flood events a levee break along the North Fork inundated the entire area with water depths up to eight feet and caused over $8 million in damages. The probable non-failure point was determined to be a 16.7 year event at a discharge of 133,000 cfs. The probable

failure point was determined to be a just over a twenty-five year event at a discharge of 146,000 cfs. Assuming the levee failure occurred at a 16.7 year event average annual damages are estimated to be $877,000. If the levee does not fail until over a twenty-five year event annual damages are estimated to be $749,000. For simplicity, an arithmetic average of the two values was used to derive an intermediate estimate of average annual damages which will be used to quantify benefits. A breakdown of the annual damages is below.

Residential Structures	$171,000
Residential Contents	82,000
Commercial/Industrial	4,000
Public	225,000
Emergency Aid	70,000
Agriculture	256,000
Other	4,000
Total	$812,000

(9) Samish Overflow. This sub-area is along the right bank of the Skagit River, north of Burlington. The flood plain includes the overflow area from the Skagit River toward the Samish River basin, but does not include Samish River flooding. Land use in this area is primarily rural with some suburban development along SR 20. The zero damage flow was determined to be 145,000 cfs, corresponding to a 25.6 year event. The PNP and PFP are assumed to be at the same elevation. Average annual damages for

this reach are estimated at $197,000 and are broken down into the following categories.

Residential Structures	$27,000
Residential Contents	11,000
Commercial/Industrial	0
Public	4,000
Emergency Aid	107,000
Agriculture	35,000
Other	13,000
Total	$197,000

(10) Nookachamps, Clear Lake, Sedro Woolley. These areas are the upper most portion of the study area considered in this evaluation and are not protected by levees. The Nookachamps and Clear Lake areas are on the left bank and Sedro Woolley is on the right bank. The zero damage point used for each area in the 1979 GDM report was also used in this evaluation. For the Nookachamps, this is approximately a two year event, for Clear Lake a 12 year event, and for Sedro Woolley a 5 year event. Damages for this reach were not broken down by category. Total expected annual damages are estimated at $342,000.

2.3 Flood Damage Reduction Alternatives.

2.3.1 No Action.

a. Description of the alternative. Under this alternative no additional measures to reduce flood damages would be undertaken, but measures already begun would be assumed to continue such as floodproofing, participation in the National Flood Insurance Program, and flood warning systems. The following assumptions were made for the no action plan.

- Flooding and flood damages would continue throughout the lower Skagit basin. The basin would continue to rely upon a 43 mile levee system extending from Burlington to the river mouth and on formal and incidental flood control by hydropower projects in the upper Skagit basin. The location of the hydropower projects will continue to limit their flood control potential because of the contribution from large uncontrolled tributaries downstream. The flood protection system was largely built over the years by landowners and provides low level frequency flood protection. Because the levees are constructed of silty, sandy soils, they frequently fail when saturated, resulting in potentially catastrophic flooding in unpredictable locations such as occurred at Fir Island in the November 1990 flood. Urban areas such as Mount Vernon and Burlington will continue to sustain major flood damages and roads in the region will continue to be flooded. The county diking districts, cities, and the Corps will continue to provide flood fight services on the levees to limit flood damages.

Some homeowners and business owners will decide to floodproof or relocate after floods, and this will slightly decrease average annual flood damages.

Skagit County participates in the National Flood Insurance Program (NFIP) and as such is subject to NFIP requirements for new development in the flood plain. These requirements include elevating new houses and floodproofing or elevating other new buildings to, or above, the 100-year flood level.

The Skagit Valley diking districts and Skagit County have a goal of improving their levees to a uniform 50-year flood frequency level of protection. However, funding difficulties have thwarted this goal. The districts will continue to maintain and repair existing levees.

Skagit County has asked the Corps to develop and improve their flood warning system for the basin under Section 205 of the 1948 Flood Control Act. Higher Corps authority approval for conducting an initial appraisal of this proposal and associated funding is pending.

Mount Vernon will continue to search for funding sources to improve levees along the downtown revetment area. This area currently overtops above a 10-year frequency flood event and requires extensive sandbagging for larger events.

b. Impacts of the Alternative.

(1) Fish. Floods carry extensive bed loads which can cover or destroy spawning beds. Silt loads can smother the invertebrates which serve as prey items for fish. Turbidity from floods during the spring can damage the gills of outmigrating juvenile salmon, which can weaken or even kill them.

Floods generally overtop or break through levees and often carry fish into agricultural fields or urban areas, stranding them. Significant impacts to both adult and juvenile fish populations can occur. For example, a large spring flood occurring in May could well result in a high percentage of young fall chinook being stranded. A significantly reduced run of returning adult fish several years later would be expected. Adult chum or steelhead migrating upstream to spawn in November and December would be stranded if a flood occurred during that period. This could significantly reduce the number of spawning fish leading to reduced runs.

In addition to the direct impacts to fish, indirect impacts would include the damage done to the fish prey items. Invertebrate populations could be dramatically reduced from burial or other disruptions. Additionally, vegetation along the river banks may be torn away, reducing the insect habitat and shading of the river.

(2) Wildlife. Flooding can also have adverse impacts to wildlife. Muskrats and beavers could lose their homes. Many small terrestrial animals would likely drown when the river banks are overtopped or breached. Predators of small animals will have reduced prey items. Repairs made to levee breaks or other flood damage typically reduces the extent of riparian vegetation, impacting wildlife species.

(3) Threatened and Endangered Species. Floods will likely impact bull trout similarly to the fish described above. No significant impacts to other endangered species are likely.

(4) Recreation. Flooding may impact recreational amenities such as hiking trails and campgrounds near the river. In the river itself, canoeing and kayaking routes could be change when channels and islands are changed. Fishing locations may be changed as well.

(5) Socioeconomics. The primary socioeconomic impact in the no action alternative would be the continuation of basin-wide flooding and associated flood damages. Commercial and residential areas in the Burlington/Mount Vernon corridor will be heavily damaged, roads will be closed, and residents will be forced to evacuate their homes and farms throughout the valley. Long

standing flood waters from levee failures will hinder agriculture and limit the types of crops which can be grown. The costs associated with the repair of flood damages diverts both private and public funds from more productive uses. However, the positive steps that the County and others are presently taking to address flood damages should minimize these increases.

(6) Cultural Resources. Cultural sites located within the flood plain would occasionally be damaged by Skagit River floods.

c. Conclusion. The no action plan does not adequately address the serious flood problem within the Skagit Basin. Since the sponsor and almost everyone within the Skagit flood plain are interested in significantly reducing flood damage, the no action plan should not be selected. This conclusion is not meant to disparage any of the positive steps that the County and others are presently taking to reduce flood damages. All these steps are important and should be continued. The conclusion is meant to suggest that even more is needed and desires by basin residents to reduce flood damages.

2.3.2 Alternative 1 - Overflow Channels

a. Description of the alternatives

(1) Background. Flooding problems are significant within the entire Skagit Basin. However, as demonstrated by the November 1990 floods, the Skagit basin from the town of Sedro

Woolley downstream is particularly susceptible to floods and flood damage. Generally, the most severe Skagit basin floods are generated when the river flooding begins to endanger Burlington and the Samish Basin and downtown Mount Vernon, as well as the existing dike system in the Lower Skagit River Valley. During the November 1990 Thanksgiving floods, water was flowing over Highway 20 between Burlington and Sedro Woolley. There was significant flooding of the Nookachamps-Clear Lake area and levees downstream of Mount Vernon were in danger of collapse. In Mount Vernon the river level rose to within six inches of the top of an emergency sandbag levee. Across the river in the West Mount Vernon area, the river had crested the levee and was being held back by sandbags and earthen berms for several miles. There was a major break in the Fir Island levee that caused over $8 million in damage. The majority of levees in the lower basin were saturated and in danger of collapse. There was also damage in the upper basin, especially in the town of Hamilton and on Cockreham Island.

The potential damage from an event that could cause a major collapse of the entire levee system (a standard project flood event) could lead to damages of up to 10 times those seen in the November 1990 floods. The major challenge in this study was to find a way to handle flows similar to, or higher than, those seen in November 1990 and minimize future flood damage to the basin. The two major alternatives that were investigated to alleviate these potential flood damages were a flood channel and a system that included a series of overtopping levees.

b. Flood Channel Alternatives. To reduce the flood damage that results from flood flows, two diversion channels were evaluated: one which included an overflow area just downstream of I-5 which would direct Skagit River flows into Samish Bay, and one which included an overflow weir located between Burlington and Sedro Woolley which also diverted excess flows into Samish Bay. The alternative located downstream from I-5 was dropped without extensive evaluation because of high costs to relocate three bridges. The other alternative, which was evaluated, included a 5,000 foot wide overflow weir and entrance channel between Sedro Woolley and Burlington transitory to a 2,000 foot wide, approximately 11 mile long flood channel down the Samish River Valley to Samish Bay (see Figure 2). This alternative would not only carry up to 80,000 cfs of Skagit River water, but would also help reduce damages due to the Samish River flooding in the lower Samish River Valley.

c. Impacts of the Alternative.

(1) Fish. The Samish flood channel would likely impact fish in the Samish River channel due to the extensive excavation of spawning and rearing habitat when widening the channel. Much of the channel is currently leveed, however the channel would be significantly widened and the removal of streamside vegetation would adversely impact the fish by removing

insect habitat and reducing shading. Mitigation for this alternative would include the establishment of low-flow rearing and refuge channels in old side slough channels. Fish from the Skagit River would likely be carried over the weir into the Samish River system during flooding events, but it is unknown if this impact would be worse than the current situation during flooding. Stranding of fish in agricultural areas would likely occur during overbank flooding causing a reduction in fish runs, however this is similar to the existing condition. The increased amounts of freshwater flowing into Samish Bay during flooding events could adversely impact eelgrass and other marine species. Any adverse impacts to fish habitat would be mitigated. All mitigation plans would be extensively coordinated with the U.S. Fish and Wildlife Service (USF&WS) and Washington Departments of Fish and Wildlife (WDF & WDW). Any in-water work would avoid the juvenile salmonid out-migration period from March 15 to June 15.

(2) Wildlife. Wildlife could be adversely impacted by the Samish flood channel if significant amounts of riparian vegetation is removed during channel widening and subsequent levee construction. Much of the by-pass channel area is in agricultural production with few trees. However, along the Samish River, there are shrubs and other vegetation that would be removed. Wetlands immediately adjacent to the Samish River would be destroyed. After completion of the channel, the land would be placed back in agricultural production which may have unknown

additional impacts on the river from runoff of fertilizers and pesticides. Continuing maintenance of the levee system would remove any large woody riparian vegetation reducing wildlife habitat. Any adverse impacts to wildlife habitat would be mitigated. Mitigation plans would be extensively coordinated with the USF&WS, WDF, and WDW.

(3) Threatened and Endangered Species. If bull trout occur in the Samish River system, they would be adversely impacted by the loss of rearing and spawning habitat. Bald eagles and peregrine falcons could be impacted during construction of the channel from noise and potential loss of prey items (small rodents, etc.). A biological assessment will be performed for all potentially impacted threatened and endangered species.

(4) Recreation. The Samish flood channel would not likely impact recreation because it would run through largely privately owned agricultural lands. Recreational amenities could be added to the project to enhance recreation over the current condition.

(5) Water Quality. Water quality would not be impacted long-term by this alternative. Flooding events cause increased turbidity which would be lessened by the overflow channel. The work in the Samish River would cause turbidity during the working period, but this will be short-term. Silt curtains or

other devices could be used, as necessary, to comply with water quality standards. After completion of the channel, the land would be placed back into agricultural production which may have unknown impacts to water quality due to runoff of fertilizers and pesticides.

(6) Cultural Resources. Alternative 1, the Samish Bay overflow channel, may directly affect 4 known cultural resource sites. Construction has a very high potential to direct affect others, probably in moderate to large numbers, on older buried surfaces. It is also very likely to affect "wet" sites, sites permanently submerged below the water table. Other sites may be affected indirectly by increased channel flow.

d. Costs and Benefits. The Samish Bypass Channel with urban levees, would provide 100 year protection to sub-areas 1, 2, 4, 5, 6, and 9 (See Figure 1). Sub-areas 3, 7, and 8 would have 50 year protection, and Sub-area 10 would be unaffected. It is currently estimated that approximately 4,000 acres of land would be needed to support alternative number 1. There are approximately 288 landowners involved. Land usages include irrigated-agricultural, residential, and commercial. The estimated value of irrigated-agricultural land is $3,000 to $4,000 per acre, and residential land is $10,000 to $20,000 per acre. This alternative has an estimated annual flood damage reduction benefits of $5,787,000. These benefits are summarized in Table 8. Costs for this alternative have been preliminarily estimated at between $100 and $130 million dollars. Based on the $100 million figure, annual costs (amortized over 100 years at 8.25%), excluding maintenance and interest during construction, are $8,253,000. The benefit to cost ratio, at best, would be 0.7 to 1.0. The study team and the sponsor did not see any additional opportunities for reducing the costs or increasing the benefits. Because of this the alternative was dropped from further consideration.

TABLE 8
ALTERNATIVE 1: BYPASS CHANNEL
FLOOD DAMAGE REDUCTION BENEFITS
OCT. 1993 PRICES AND CONDITIONS

ECONOMIC SUB-AREA	EXISTING	WITH PROJECT	
	AVERAGE ANNUAL DAMAGES	RESIDUAL DAMAGES	FLOOD DAMAGE REDUCTION BENEFITS
1. RIGHT BANK U/S PULVER ROAD	$1,066,000	$686,000	$380,000
2. RIGHT BANK D/S PULVER ROAD	$636,000	$318,000	$318,000
3. RIGHT BANK D/S RURAL	$539,000	$433,000	$106,000
4. WEST MT. VERNON	$787,000	$326,000	$461,000
5. BIG BEND (N. MT VERNON)	$1,050,000	$446,000	$604,000
6. MAIN MT. VERNON	$3,525,000	$721,000	$2,804,000
7. LEFT BANK D/S MT. VERNON	$1,003,000	$389,000	$614,000
8. FIR ISLAND	$812,000	$399,000	$413,000
9. SAMISH OVERFLOW	$197,000	$110,000	$87,000
10. OTHER AREAS NOOKACHAMPS, CLEARLAKE SEDRO WOOLEY	$342,000	$342,000	$0
TOTAL	$9,957,000	$4,170,000	$5,787,000

2.3.3 Alternative 2 - Urban Flood Control and Levees with Control Structures in Rural Areas. (Selected Alternative)

a. Description of the alternative

(1) Background. During the reconnaissance study two of the county commissioners came forward and recommended an alternative that would include a high level of protection (100 years) for the urban areas of the lower basin (sub areas 1, 4, 5 and 6) and a system of new and raised levees with overflow sections (or control structures) at critical locations in rural areas designed to overtop without failure. The level of protection for rural areas would be up to the 25 year event, greater than currently exists but significantly less than for the urban areas. This alternative was recommended because the commissioners believed that the other alternatives that have been studied in the past were beyond the financial capability of the county. They also believed that a system had to be considered that would ensure that the undeveloped areas of the county would remain rural and not be removed from the 100 year flood plain, thus becoming open to development. The system also had to protect against catastrophic levee failures during higher floods such as the one that occurred on Fir Island in the November 1990 floods.

(2) Alternative Elements. This alternative would provide 100 year level of flood control protection through urban levee development and 25 year flood protection in rural areas with

sections of overflow levees (control structures). It consists of the following:

- Construction of a 5,000 foot levee with a control structure south of the town of Sterling (see Plate 2).

- Construction of 3,500 linear feet of new levee southeast of Sterling to an average height of 5.5 feet (see Plate 2).

- Construction of 36,000 feet of new levee around Burlington. Height ranges from 5.5 feet to 4.0 feet (See plate 2).

- Upgrading the existing bankside levee (22,500 feet) in the Burlington area (see Plate 2).

- Excavating of a 6,000-foot-long segment of right river bank between the Burlington Northern railroad and I-5 and setting the existing levee between sections back an average distance of 250 feet. This channel enlargement would require adding an additional pier to Highway 99 and railroad bridge. The existing I-5 bridge has enough clearance to handle the enlarged channel size (see Plate 2).

- Construction of 3 levee sections with control structures: one just downstream of Burlington, one just upstream of West Mount Vernon on the right bank, and one just downstream of Mount Vernon on the left bank (see Plate 3).

o Construction of two levee segments totaling 15,500 linear feet, to protect urban areas of Mount Vernon. Height of these levees would vary from 4.5 feet to 3.5 feet, providing 100 year protection to the Big Bend area. This area would require strict zoning restrictions to ensure that no significant development would take place in this rural area (see Plate 3).

o Upgrading of 63,900 feet of existing bankside Mount Vernon levees including construction of concrete tilt up flood walls in the revetment area of Mount Vernon (see Plate 3).

o Construction of a 6,000 foot long levee section with control structure on the North end of Fir Island (see Plate 4).

o Upgrading of both the existing levees (34,000 linear feet South Fork and 27,000 linear feet North Fork) on Fir Island and levees adjacent to Fir Island on the Mainland (42,000 linear feet South Fork and 17,000 linear feet North Fork) (see Plate 4).

o Numerous additional pumps and drainage structures throughout the entire proposed project.

It is presently estimated that approximately 455 acres of land would be needed to support Alternative 2. Appendix 4 provides details on real estate concerns for Alternative 2.

Skagit County has asked the Corps to prepare a flood warning system for the basin (action pending approval by Corps higher authority). The system would have to be refined with Alternative 2 to tie into the levee overflow area.

The impact of these improvements would be to reduce flood damages in the Skagit Valley. If these improvements had been in place during the November 1990 floods the $30 to $40 million in flood damages in the lower Skagit Basin would have been significantly reduced. For floods larger than the November 1990 events (up to the 100 year flood event), the towns of Burlington, Mount Vernon and West Mount Vernon would be protected and the flooding in the remainder of the flood plain would be limited to 2 to 3 foot depth range. Catastrophic levee failures and the resulting potential for significant loss of life and property would be eliminated in up to the 100 year flood event.

With the above project in place floods of 146,000 cfs (measured at Mount Vernon) would be confined to the river channel and unleveed areas of the basin. In flood flows higher than 146,000 cfs, the control structures would begin to pass water over them. Overtopping in this area would allow flooding depths from several inches up to 3 feet in a 100 year flood event. In the 100-year flood event, the flows entering the upstream end of this system would be approximately 235,000 cfs.

b. Impacts of the Alternative

(1) Fish. The urban ring levees would not significantly change the existing highly modified and degraded riverbanks near Burlington and Mount Vernon. In fact, the project could enhance fish habitat over existing conditions by incorporating in-water habitat structures and vegetation plantings along the levee banks. During flood events, fish would likely be washed over the control structures and stranded in agricultural areas. However, this impact would be less frequent than the current condition. The overflow sections would be significantly wider than regular levee sections and would require the removal of riparian vegetation. Additionally, the control structures would also take water in 25 year flood events that would cause stranding of fish less frequently than the existing condition. Any adverse impacts to fish would be mitigated with extensive coordination with USF&WS, WDF, and WDW. Any in-water work would avoid the juvenile salmonid out-migration period from March 15 to June 15. Possible mitigation could include development of a return channel and gate to return stranded fish to the main river.

(2) Wildlife. Impacts to wildlife resources would be primarily limited to the construction areas. Wildlife downstream of the levee sections would experience somewhat reduced flood stages. The continued maintenance of the levee structures

will remove any large woody riparian vegetation. This would reduce wildlife habitat in the project area. Any adverse impacts to wildlife would be mitigated with extensive coordination with USF&WS, WDF, and WDW.

(3) Threatened and Endangered Species. This alternative may remove nesting and perching trees utilized by bald eagles or peregrine falcons. A biological assessment would be required for all potentially impacted threatened or endangered species.

(4) Recreation. This alternative would not likely impact recreation facilities or opportunities in the Skagit basin. Additionally, recreation could be significantly enhanced if bike trails are incorporated into the levee design. Existing levees along the Skagit River are largely closed to public access. The improvement of levees along both sides of the Skagit River as proposed by this study, would provide an opportunity for an expanded bike and pedestrian trail system with possible mini parks and restroom facilities and would tie into existing and proposed riverine trail systems. These would facilitate the growing use of the Skagit valley by cyclists, hikers, and bird watchers.

(5) Water Quality. Water quality will not be impacted long-term by this alternative. Any in-water levee construction/improvement could cause temporary water quality impacts mainly through increased turbidity, but this will be short-

term. Coordination of construction windows and water quality monitoring of construction will be coordinated with the appropriate fish and wildlife agencies.

(6) Cultural Resources. All impacts are on sites known as of 1981; other sites not in our current inventory may have been discovered and reported since then. The Burlington-Sterling levee may directly affect two known cultural resource sites. Through increasing channel flow velocities, it may affect two known sites indirectly. Other unknown or buried sites also may be affected either directly or indirectly. The Mount Vernon levees may directly affect 5 known cultural resource sites. Increasing channel flow velocities may indirectly affect one known cultural resource site. Other unknown or buried sites also may be affected either directly or indirectly. Prior to any modification of terrain for a Corps project, systematic surface archeological surveys and subsurface probes should be completed to prevent inadvertent destruction of prehistoric or significant historic sites. All cultural resource impacts are on sites known as of 1981; other sites not in our current inventory may have been discovered and reported since then. The Fir Island levees may directly affect 13 known cultural resource sites. Through increasing channel flow velocities, they may indirectly affect two known cultural resource sites. Other unknown or buried sites also may be affected either directly or indirectly.

(7) <u>Native American Concerns</u>. Impacts of the alternatives on Native American treaty fishing rights are not known and would have to be identified during subsequent study. Projects generally would have to be designed and constructed to have no net loss to the resource. In response to Skagit County's request that the scope of the study to be widened to include a comprehensive, basin-wide approach, the tribes are seeking opportunities to restore areas lost from fish production throughout the study area.

c. <u>Hydrology</u>. This alternative includes building a ring-dike around the town of Burlington and a portion of Mount Vernon. As a result, it was necessary to determine the amount of water that accumulates from a hypothetical 100 year/24 hour and 100 year/72 hour storm for this area. A conservative analysis of the runoff was performed in order to estimate order-of-magnitude sizing of pumping facilities that would be needed to adequately evacuate local storm water from the areas enclosed by levees. The approximate volumes of water from these hypothetical storms are shown in Table 9.

TABLE 9

POTENTIAL STORM WATER PONDING VOLUMES (levee enclosed areas)

Interior Areas	Area (Acres)	Precip. Depth for 100 yr/24 hr Storm (FT)*	Total Volume (Acre-Feet)
Burlington	3956	.333	1316
W. Bank of Skagit R.	330	.333	110
S.W. Mount Vernon	680	.333	226

Interior Areas	Area (Acres)	Precip. Depth for 100 yr/72 hr Storm (FT)*	Total Volume Acre-Feet)
Burlington	3952	.467	1845
W.Bank of Skagit R.	330	.467	154
S.W. Mount Vernon	680	.467	318

*Estimated based on Standard Project Precipitation depth ratios.

d. Inundation Reduction Benefits. The Skagit River Urban levee alternative with rural levees and control structures has total estimated average annual flood damage reduction benefits of $4,892,000. Table 10 summarizes the existing condition damages, residual damages, and damages reduced by this alternative. Overall, the urban areas of Burlington (sub-area 1), West Mount Vernon (4), Main Mount Vernon (6), and a portion of North Mount Vernon (5) would all receive 100 year flood protection from this alternative. The remaining sub-areas would receive complete protection from floods less than or equal to a twenty five year flood event with the exception of sub-areas 9 and 10 which would be unaffected by the selected plan. For floods exceeding the 25 year frequency, areas adjacent to the overflow levees would begin to be inundated. A reduction in damages over existing conditions is expected for flows between a 25 year flood event and a 100 year flood because the existing system would be protected against catastrophic, unpredictable levee failures, which can result in high velocity flows and keep, long duration flooding. With Alternative 2 the areas of controlled overtopping can be pre-selected for minimal impact and a sound flood warning floodproofing program can be developed for these areas. Once a 100 year flood discharge is reached flooding would reflect pre-project conditions, but damage to levees would be minimized. Alternative 2 flood damage reduction benefits for each sub-area are broken down by category below.

TABLE 10
ALTERNATIVE 2
URBAN AND RURAL LEVEES WITH CONTROLLED OVERFLOW SECTIONS
ECONOMIC ANALYSIS BY SUB-AREAS
(OCT. 1993 PRICES AND CONDITIONS)

ECONOMIC SUB-AREA	EXISTING AVERAGE ANNUAL DAMAGES	RESIDUAL DAMAGES	DAMAGES REDUCED (BENEFITS)
1. RIGHT BANK U/S PULVER ROAD	$1,066,000	$686,000	$380,000
2. RIGHT BANK D/S PULVER ROAD	$636,000	$582,000	$54,000
3. RIGHT BANK D/S RURAL	$539,000	$525,000	$14,000
4. WEST MT. VERNON	$787,000	$326,000	$461,000
5. BIG BEND (N. MT VERNON)	$1,050,000	$446,000	$604,000
6. MAIN MT. VERNON	$3,525,000	$721,000	$2,804,000
7. LEFT BANK D/S MT. VERNON	$1,003,000	$626,000	$377,000
8. FIR ISLAND	$812,000	$634,000	$178,000
9. SAMISH OVERFLOW	$197,000	$197,000	$0
10. OTHER AREAS HOOKACHAMPS, CLEARLAKE SEDRO WOOLEY	$342,000	$342,000	$0
TOTAL	$9,957,000	$5,085,000	$4,872,000

(1) Right Bank Urban Upstream of Pulver Road (Burlington). This area would receive 100 year flood protection from the selected alternative. Going from 25 year to 100 year flood protection would also reduce floodproofing costs for future development. This is addressed in a later section. Flood damage reduction benefits for present land use are listed below:

Residential Structures	$104,000
Residential Contents	50,000
Commercial/Industrial	56,000
Public	28,000
Emergency	69,000
Agriculture	6,000
Other	67,000
Total	$380,000

(2) Right Bank Downstream Pulver Road. This area would have a 25 year flood event overflow levee section with the selected alternative and would receive complete protection up to this event. Once this discharge is exceeded and the levee section overtops, the path of flooding would be much more predictable, and there would be a substantial reduction in damage to flood protective works. The overall level of flood protection would increase from the current 20 year protection to 25 year with project, with benefits totaling $54,000.

Residential Structures	$ 13,000

Residential Contents	6,000
Commercial/Industrial	7,000
Public	7,000
Emergency Aid	14,000
Agriculture	6,000
Other	1,000
Total	$ 54,000

(3) Right Bank Downstream Rural. With the proposed levee improvements in place, this sub-area would begin flooding at a 25 year event, rather than the current 20 year flood event. Benefits are broken out below:

Residential Structures	$ 1,000
Residential Contents	1,000
Commercial/Industrial	2,000
Public	0
Emergency Aid	2,000
Agriculture	8,000
Other	0
Total	$ 14,000

(4) West Mount Vernon. This area would receive 100 year flood protection under the selected alternative, excluding the area riverward of the existing levee. Inundation reduction benefits are estimated at $461,000 and broken out below:

Residential Structures	$128,000

Residential Contents	59,000
Commercial/Industrial	220,000
Public	24,000
Emergency Aid	23,000
Agriculture	2,000
Other	5,000
Total	$461,000

(5) North Mount Vernon. Under the selected alternative, the Big Bend area would receive 100 year protection. Over 1/3 of the benefits accrue to the commercial/industrial category. Average annual benefits are broken out below:

Residential Structures	$ 67,000
Residential Contents	31,000
Commercial/Industrial	200,000
Public	76,000
Emergency Aid	194,000
Agriculture	28,000
Other	8,000
Total	$604,000

(6) Main Mount Vernon. The city of Mount Vernon would receive 100 year flood protection from the proposed project. Average annual benefits are estimated at $2.8 million and are broken into the following categories:

Residential Structures	$967,000

Residential Contents	470,000
Commercial/Industrial	790,000
Public	80,000
Emergency Aid	451,000
Agriculture	5,000
Other	41,000
Total	$2,804,000

(7) Left Bank Downstream Mount Vernon. A 25 year level of protection overflow levee section would be located on the upstream end of this sub-area. Overall, the level of protection in this area would increase from a 10.5 year event to a 25 year event. A small reduction in damages for flood events between 25 year and 100 year flood event, would also benefit this sub-area. Existing condition damages of over $1 million would be reduced to $626,000, leaving a net benefit of $377,000.

Residential Structures	$ 85,000
Residential Contents	58,000
Commercial/Industrial	52,000
Public	79,000
Emergency Aid	21,000
Agriculture	73,000
Other	9,000
Total	$377,000

(8) Fir Island. This area has the fifth overtopping

levee section. The level of protection for this sub-area would be 25 year flood protection with the project in place. Flood damage reduction benefits are expected from an increase in the level of protection, as well as more predictable flooding which would tend to decrease damages, especially those to levees. A breakdown of the benefit categories is listed below:

Residential Structures	$ 35,000
Residential Contents	17,000
Commercial/Industrial	1,000
Public	42,000
Emergency Aid	30,000
Agriculture	52,000
Other	1,000
Total	$178,000

(9) Samish Overflow. Benefits for this area are assumed to be zero. The area would be expected to continue to flood at a 25 year flood event. A detailed hydraulic model would be developed in the feasibility phase to test the assumption that the proposed project would not induce additional damage in the Samish Basin.

(10) Other Areas. These areas are assumed to be unaffected by the project. Therefore, no flood damage reduction has been taken for this sub-area. Again we will test this assumption with a model in the feasibility phase.

e. <u>Other Benefit Categories</u>. Skagit County, one of the state's fastest growing counties, has a year 2010 projected population of 131,885 which is a 54% increase over current population and represents an average growth rate of 2.9% per year. Between the years 2010 and 2040 the Skagit County Planning Department is projecting population growth to slow to an average of 1% per year. Mount Vernon has an expected average growth rate of 4.1% over the next eighteen years, and 1.3% for the following 30 years. Current Mount Vernon population is 19,934. Projected population for the year 2010 is 34,478, and 48,007 in the year 2040. Burlington is also expected to grow at a rate higher than the county average, with a projected growth rate of 3.2% per year through 2010, and .4% to the year 2040. Current 1992 population of 4,510 is projected to grow to 6,231 in the year 2040. With these large population increases, a significant amount of development is expected to occur within the project area.

Skagit County is planning under Washington State's Growth Management Act. As such, the county is required to establish urban growth areas and encourage future development within these boundaries. In Skagit County, the cities of Mount Vernon and Burlington are two of these areas, as is the I-5 corridor connecting the cities. The county's goal is to have 80% of new development to occur in these urban growth areas as opposed to losing additional rural/agricultural land to development in other parts of the county. Historically, approximately 50% of the growth has occurred in rural areas and 50% in urban areas. Economic sub-areas 1 (Burlington), 4 (West Mount Vernon), 6 (main Mount Vernon), and a portion of 5 (North Mount Vernon) coincide with the county's urban growth planning boundaries. The effect of the proposed flood control project in relation to future development is discussed below.

(1) Location and Intensification Benefits. Location and intensification benefits were investigated for the flood plain areas affected by the proposed project, particularly those which would receive 100 year protection by the project. Location benefits are the value of making flood plain land available for higher economic use by reducing flood hazards to activities which would use the flood plain only with flood protection. Intensification benefits are the value associated with a plan which enables existing flood plain activities to utilize land more intensively. Currently the flood plain in economic sub-areas 1 (Burlington), 4 (West Mount Vernon), 5 (a portion of North Mount Vernon), and 6 (Mount Vernon) is a combination of rural agricultural development and typical urban (commercial/industrial and residential) development. Under the county's long range plan, most of the land within the above-mentioned sub-areas will be further developed with land use changing from suburban and rural to commercial/industrial and to a lesser degree residential use. It appears that rural land values in these areas presently reflect future development, and this development will take place with or without the project. As such, at this level of study, it is

assumed that no significant amount of land is anticipated to change use or go to a higher or more intensive use as a direct result of the proposed project. The growth will likely take place with or without the project.

(2) Elimination of Floodproofing Costs. Benefits for the elimination of future floodproofing costs were investigated for economic sub-areas 1, 4, 5, and 6 which would receive 100 year protection from the proposed project. Within these areas there is an estimated 900 acres that would be developed or further developed. Within the Burlington area this includes an estimated 575 residential structures and 130 commercial establishments over the next 50 years. Around the Mount Vernon area there will be an estimated 130 new commercial/industrial structures developed over the next 50 years. Under current Federal flood control laws, all new development in the flood plain is required to be floodproofed up to the 100 year event. With the project in place the projected new development would experience a cost savings from the elimination of floodproofing structures. Benefits were based on raising structures an average of 4 feet by hauling in fill material. The average cost to floodproof a commercial structure has been estimated at $80,000. The average cost for floodproofing residential structures is estimated at $4,500 per structure. The present value of the annual cost-saving, with growth occurring uniformly over the next fifty years, and annualized over the project life at 8.25% results in an annual benefit of $408,000 for

commercial development and $51,000 for residential development for a total benefit of $459,000.

f. Project Justification. The first costs associated with the selected alternative (urban levees and rural levees with control structures) are $49,300,000. Estimates of annual charges are based on a 100 year period of analysis or economic life. Interest during construction has been included in the total investment cost and was compounded on an annual basis over a two year period. Interest and amortization charges are based on a 8.25% interest rate. Annual operation and maintenance expenditures are estimated at $295,000. A summary of annual costs and benefits are presented in Table 11. This alternative results in a positive benefit-to-cost ratio of 1.1 to 1.0. A line item cost breakdown is shown in Table 12, and Appendix 3 has a detailed cost estimate.

TABLE 11

SUMMARY OF ANNUAL BENEFITS AND COSTS
OF SELECTED ALTERNATIVE
(October 1993 Prices)

Investment Costs	
Initial Construction Cost	$49,300,000
Interest during Construction	4,100,000
Investment Cost	$53,400,000
Annual Costs	
Interest and Amortization (@ 8.25% - 100 yrs)	$ 4,407,000
Operation and Maintenance	295,000
Annual Cost	$ 4,702,000
Average Annual Benefits	
Inundation Reduction Benefits	$ 4,872,000
Elimination of Floodproofing Costs	459,000
Annual Benefit	$ 5,331,000
Benefit-to-Cost Ratio	1.1 to 1.0

TABLE 12

SUMMARY OF PROJECT COST ESTIMATE
(October 1993 Price Level)

FEDERAL & NON-FEDERAL COSTS

ACCOUNT NO.	FEATURE	COST	CONTINGENCY (25%)	AMOUNT
06	Fish & Wildlife (6%)	$1,400,000	$400,000	$1,800,000
11	Levees and Floodwall			
	A. Region I: Burlington	$15,800,000	$4,000,000	$19,800,000
	B. Region II: Mt. Vernon	$7,500,000	$1,900,000	$9,400,000
	C. Region III: Sedro Woolley	$300,000	$100,000	$400,000
14	Cultural Resources (1.5%)	$400,000	$100,000	$500,000
	SUBTOTAL	$25,400,000	$6,500,000	$31,900,000
01	Lands & Damages	$10,000,000	$2,000,000	$12,000,000
30	Engineering and Design (10%)	$2,500,000	$600,000	$3,100,000
31	Supervision and Administration (7%)	$1,800,000	$500,000	$2,300,000
	TOTAL PROJECT COST:	$39,700,000	$9,600,000	$49,300,000
	Maintenance / year			$295,000

APPROVED

Chief, Cost Engineering Branch

Date 4/27/93.

g. Conclusions: Alternative 2 appears to warrant further investigation. The reconnaissance phase economic analysis yielded a benefit-to-cost ratio of 1.1 to 1. The potential project appears to have a Federal interest and to warrant further study. In addition, if the project were constructed, the estimated local share ($11,000,000) of the total construction cost ($49,300,000) appears to be affordable to Skagit County, and the environmental impacts seem minimal. Based on the study findings, the potential project would significantly reduce flood damages in the Skagit Basin.

2.3.4 Alternative 3. During the final stages of preparation of the reconnaissance report a recommendation was made to look at higher levels of protection than that afforded by the 25 year overtopping levees. There are flood damage reduction benefits to be obtained with a higher overtopping levee, and the cost of increasing the height of these levees might be small compared to the benefits obtained. The major problem with this alternative was that it would cause significant additional flooding of the Nookachamps/Clear Lake area by increasing the height of the overtopping levee on the other side of the river (see Plate 2). A possible solution to this problem would be to include a levee to protect the majority of the Nookachamps/Clear Lake area that would include an overtopping section at the same flooding elevation as the rest of the adjacent and downstream overtopping sections. The investigation of this alternative would include an analysis of the natural valley storage lost with this alternative and whether or not a pumping plan would be required on Nookachamps Creek (see Plate 5 for a possible levee location for this alternative).

3. Conclusions.

This reconnaissance report finds that an economically feasible solution exists for partial flood damage reduction in the Skagit basin. The solution includes a series of levees that would protect Burlington, Mount Vernon, and West Mount Vernon from a 100 year flood event and a series of rural levee upgrades with overflow control structures that would protect the rural areas from all flooding up to a 25 year event. The project would also minimize the chance of a catastrophic flood for events higher than the 25 year flood event. The plan would reduce average annual flood damages in the Skagit Basin by $ 4,872,000 (from $9,957,000 to $5,085,000). These improvements would cost about $49,300,000, which would be cost shared at about 25 percent non-Federal and 75 percent Federal. The local sponsor (Skagit County) favors this plan as a basis for further evaluation and for further consideration of other alternatives in the subsequent feasibility phase. Study findings indicate there is a Federal interest in pursuing further studies of flood damage reduction measures in the Skagit Basin. There is also a significant local interest in pursing feasibility studies based on a significant public involvement program that was sponsored by Skagit County.

4. Proposed Feasibility Studies.

Several proposals for studies in the feasibility phase have already been discussed in this report. Additional studies would include:

o More detailed studies to establish the basic design and cost of rural flood control and overtopping levee section alternative. Further studies to investigate possible flood damage reduction alternatives upstream of Sedro Woolley, concentrating on non-structural alternatives (e.g. flood warning and floodproofing).

o Fish and wildlife studies to establish suitable mitigation measures for any Corps structural project, and basin-wide fish and wildlife studies to explore enhancement opportunities.

o Detailed hydraulic and hydrologic studies to accurately establish the present flood patterns and characteristics, hydrologic data, and the impact of the Corps' flood damage reduction alternative. Analysis would include development of unsteady and possibly two-dimensional modeling procedures and investigation of upstream storage potential. Also a detailed hydrologic analysis of the existing flood control operation and existing flood control storage at Seattle City Light's Ross and Puget Power's Upper Baker hydropower projects is required.

o Detailed design analysis to establish design of the overtopping levee sections to possibly include physical model studies.

o Geotechnical studies to establish the reliability of existing levees, materials needed for new levees, and suitable borrow sources for any new levee material.

o Detailed hydraulic analysis of levee failure sequencing and downstream effects.

o Detailed surveying and mapping for all areas where a Corps project would be built, and other areas along the river as necessary for input to the hydrologic and hydraulic studies.

o Real estate studies to establish the real estate costs for all land needed for the Corps project.

o Economic studies to refine the economic analysis and feasibility of the potential project.

o Studies to define and incorporate hydrologic, hydraulic, and economic risk and uncertainty into all appropriate project elements including a risk and uncertainty approach to determine with-project level of protection.

o Evaluation of nonstructural measures (floodproofing, relocation, and flood warning systems) for the areas unprotected by levee projects, and a refined flood warning system for the lower basin to tie into the existing and proposed levee systems.

o A study to determine if an alternative with a higher protection level for the control sections and a levee across the mouth of the Nookachamps area is feasible.

o A public agency, Indian tribe, and local sponsor public involvement program.

At present, it is estimated that the feasibility phase would last three years and cost about $2,500,000. This time frame and cost estimate will be refined in the next few months and presented in the Initial Project Management Plan (IPMP) which will be forwarded, along with the Draft Feasibility Cost Sharing Agreement (FCSA) and Letter of Intent (LOI), to satisfy certification requirements.

While the feasibility study is underway the County is planning to update its comprehensive flood damage reduction plan. This plan will address aspects that are currently outside the scope of the proposed feasibility study. (logging practices, zoning in certain areas, etc.)

5. <u>Division of study and project responsibilities</u>.

The feasibility study phase would be equally cost-shared between the local sponsor (Skagit County) and the Federal Government under the provisions of Public Law 99-662. Up to 50 percent of the local non-Federal cost-sharing may be through "in kind" services. At least 50 percent of the non-Federal share must be in "cash" contribution. If the non-Federal share of the feasibility cost were $1,250,000, then at least $612,500 would have to be in cash.

During the next phase, plans and specifications, project construction details would be developed by the Corps in enough detail so that the project could then be turned over to a contractor for construction. The plans and specifications phase are cost shared with the sponsor at the same ratio as the construction phase, which is typically 75% Federal, 25% non-Federal. However, the local costs under the plans and specifications phase are deferred until the construction phase.

The final phase is project construction, for which costs are typically shared 75% Federal and 25% non-Federal. When LERRD (lands, easements, rights-of-way, relocations and disposal sites) costs are high in relation for the total project, the non-Federal cost can be as high as 50%, but it can never exceed 50%. Assuming a relatively low LERRD cost, a $49,300,000 project could require a minimum of $11,000,000 contribution from the local sponsor.

The potential local sponsor, Skagit County, is aware of and is willing to accept its cost sharing responsibilities. A county-wide Citizens Committee has been established by Skagit County to bring about a comprehensive approach to flood damage reduction. The Committee has been established in part to assist the Corps in their development of reconnaissance and feasibility studies. The Committee has fully supported the reconnaissance study and is working toward the initiation of a feasibility study. Funding of the non-Federal portion of the feasibility study phase, would come from county funds. The plans and specifications phase, and the construction phase would likely be funded through a local bond issue.

6. Study participants and coordination.

This study was conducted under the management of the Seattle District Corps of Engineers. The overall management responsible for this effort was:

Colonel Walter Cunningham, District Engineer
Philip O'Dell, Chief, Engineering Division
George Ploudre, Chief, Planning Branch
Frank Urabeck, Chief, Plan Formulation Section

The reconnaissance investigation was conducted by the Corps study team consisting of the following:

Noel Gilbrough, Plan Formulation Section, Study Manager
Mike Scuderi, Environmental Resources Section
Merri Martz, Environmental Resources Section
Patty Cardinal, Economics Section
Norm Skjelbreia, Civil Design Section
Monte Kaiser, Geotechnical Branch
Wanda Gentry, Real Estate Division
Linda Smith, Plan Formulation Section
Joanne Green, Plan Formulation Section
Dan Harvey, Hydrology Section
Kim Scattarella, Hydrology Section
Jim Lencioni, Hydraulics Section
Ron Malmgren, Hydraulics Section
Steve Pierce, Cost Engineering Branch
Lawr Salo, Environmental Resources Section, Cultural Resources
Jim Smith, Economics Section

The local sponsor, Skagit County, provided valuable help and ideas throughout the reconnaissance study. In particular we would like to recognize:

Robby Robinson, County Commissioner

Bob Hart, County Commissioner

Harvey Wolden, County Commissioner

Dave Brookings, County Flood Engineer

Agency and Indian personnel that have been particularly helpful during the study include:

Steve Fransen, US Fish & Wildlife Service

Kurt Buchanan, Department of Fisheries

Larry Wasserman, Skagit System Cooperative

Marcia Giedel, State Department of Ecology

George Kominsky "

Terry Stevens "

John Gennett, Washington Department of Wildlife

Jim Chue, U. S. Forest Service

The Skagit River Flood Control Citizens Committee was instrumental in keeping the study team up-to-date on study and project developments throughout the basin. The Citizens Committee's information has been useful in preparing this reconnaissance report. The current president of the Citizens

Committee is Neil Hamburg and the chairman of the Reconnaissance Study Subcommittee is Richard Smith.

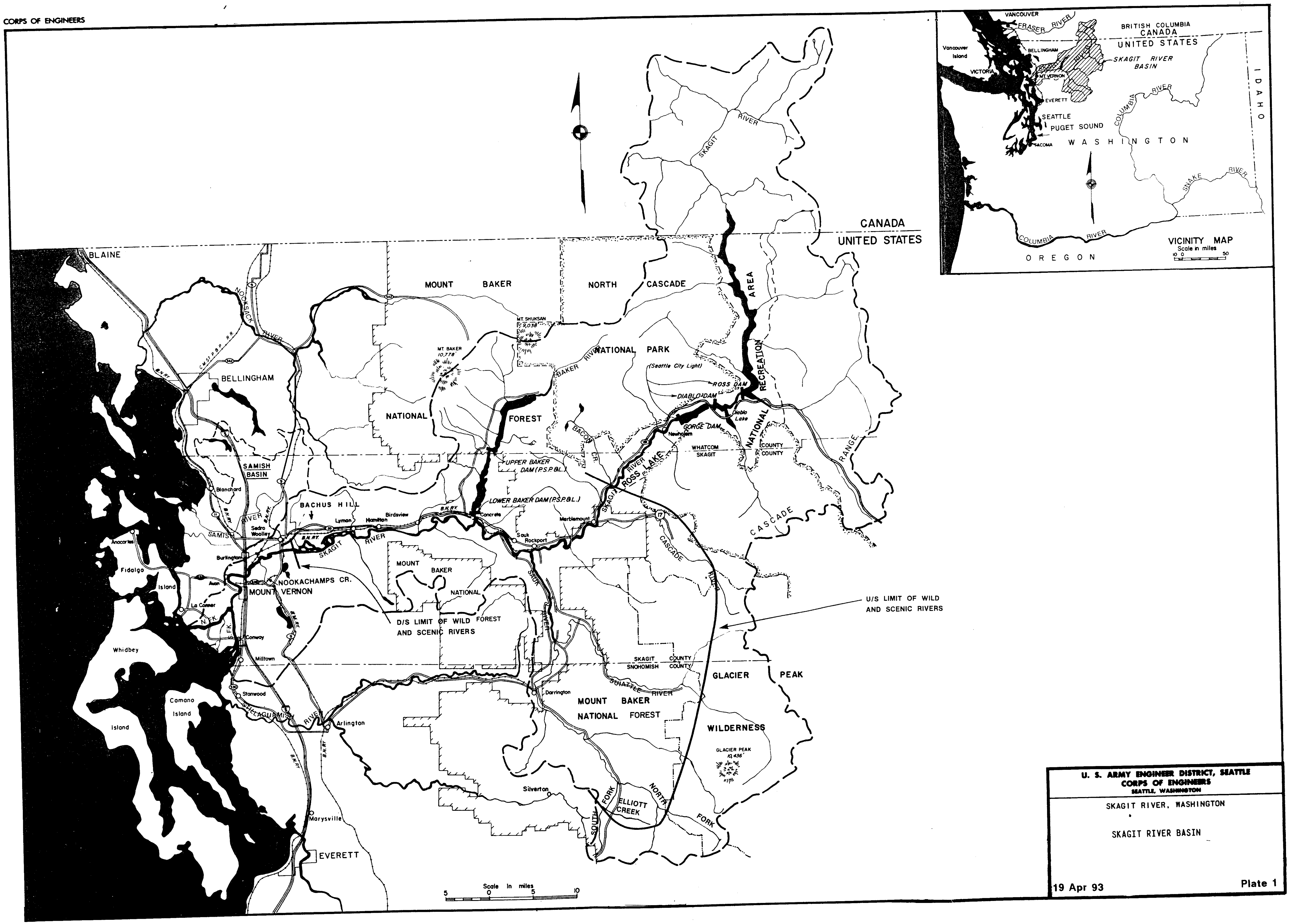
Since the study began in April 1992, some of the most important coordination events (other than the monthly Citizens Committee Meetings) have included a series of public workshops that have been held throughout the Skagit Basin on this issue.

Several interagency meeting were conducted at the County offices. The following were represented at those meetings: US Forest Service, Skagit System Cooperative (representing the Swinomish, Upper Skagit and Sauk/Suaittle Tribes) US Fish and Wildlife Service, Department of Wildlife, and the Department of Ecology.

7. Recommendations.

I recommend that a cost-shared feasibility study be initiated to investigate, in detail, flood damage reduction measures for the Skagit basin. This detailed feasibility study would be conducted in accordance with the Water Resources Development Act of 1986 (Public Law 99-662).

Walter J. Cunningham, P.E.
Colonel, Corps of Engineers
Commanding



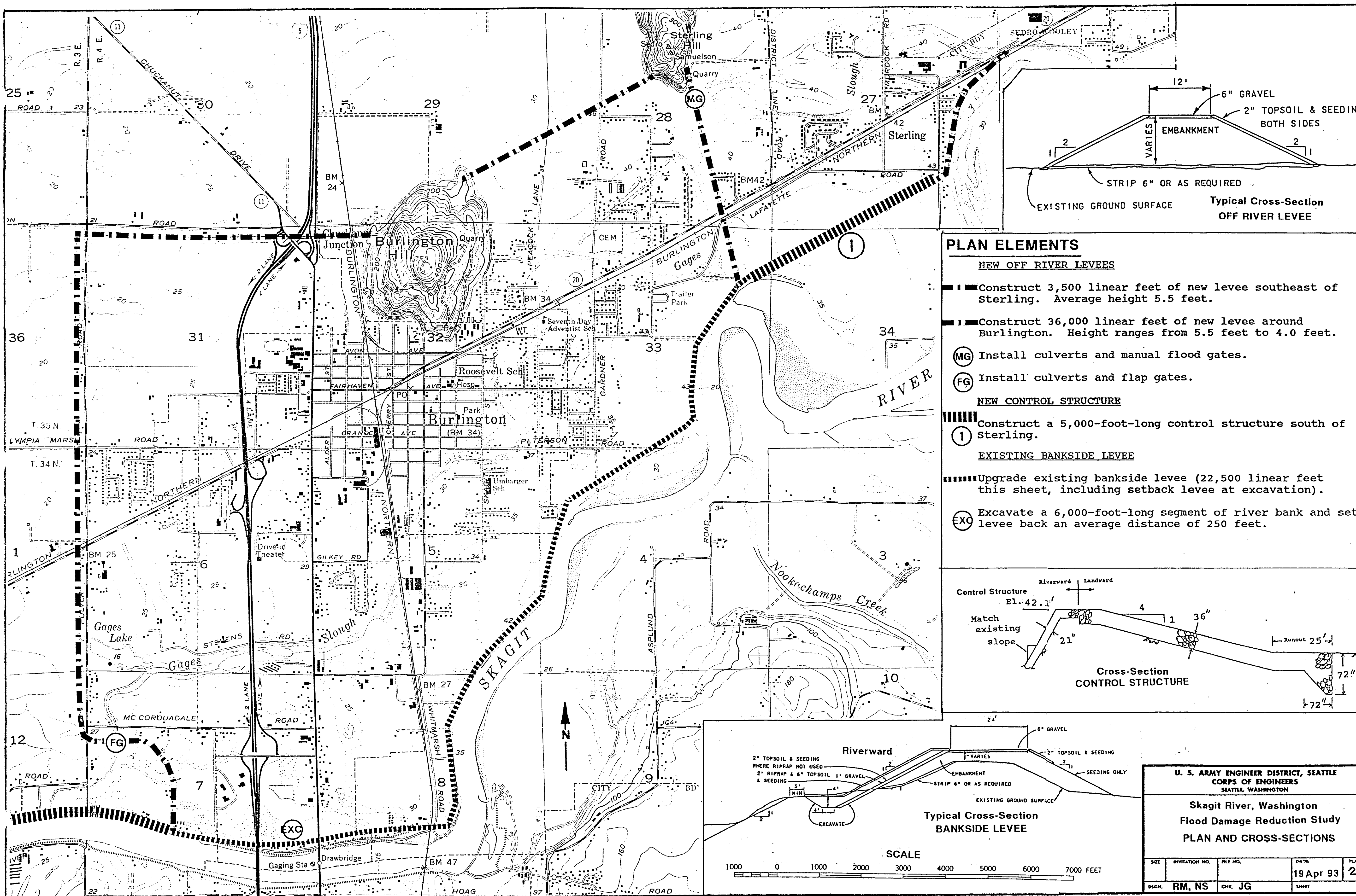
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

SKAGIT RIVER, WASHINGTON

SKAGIT RIVER BASIN

19 Apr 93

Plate 1



PLAN ELEMENTS

NEW OFF RIVER LEVEES

Construct 3,500 linear feet of new levee southeast of Sterling. Average height 5.5 feet.

Construct 36,000 linear feet of new levee around Burlington. Height ranges from 5.5 feet to 4.0 feet.

(MG) Install culverts and manual flood gates.

(FG) Install culverts and flap gates.

NEW CONTROL STRUCTURE

(1) Construct a 5,000-foot-long control structure south of Sterling.

EXISTING BANKSIDE LEVEE

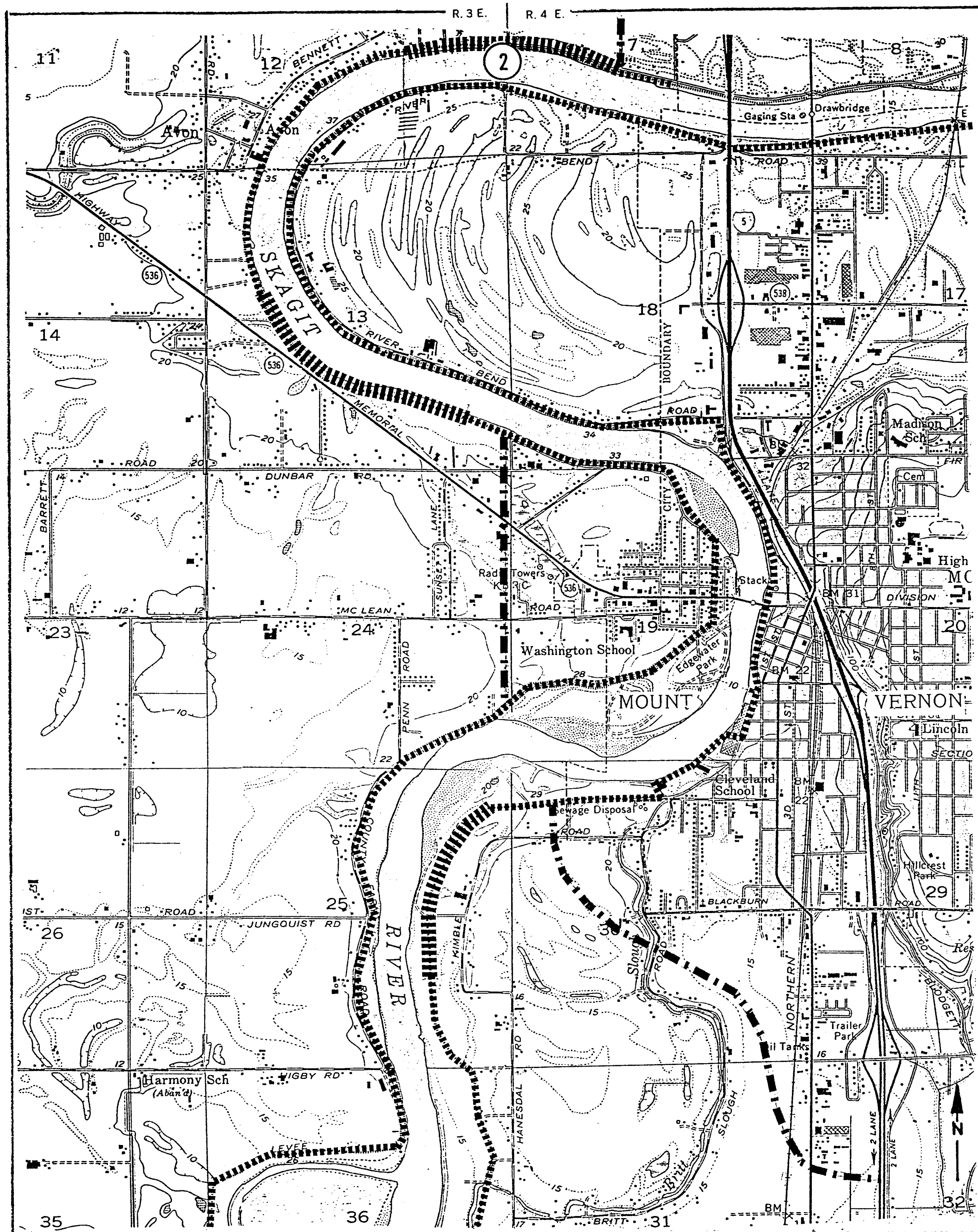
Upgrade existing bankside levee (22,500 linear feet this sheet, including setback levee at excavation).

(EXC) Excavate a 6,000-foot-long segment of river bank and set levee back an average distance of 250 feet.

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

Skagit River, Washington
Flood Damage Reduction Study
PLAN AND CROSS-SECTIONS

SIZE	INVITATION NO.	FILE NO.	DATE	PLATE
			19 Apr 93	2
DSGN. RM, NS	CHK. JG			SHEET



PLAN ELEMENTS

NEW OFF RIVER LEVEES

Construct two levees, totalling 15,500 linear feet, to protect urban areas. Height varies from 4.5 feet to 3.5 feet, upstream to downstream.

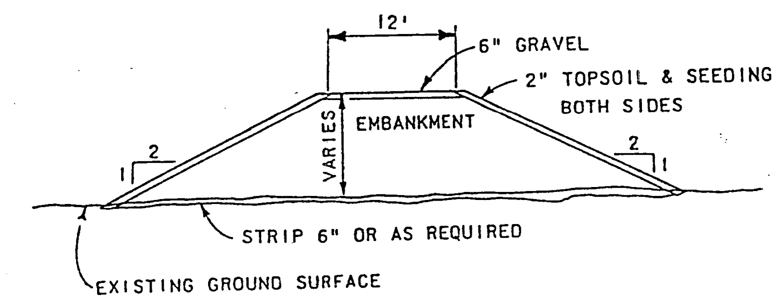
NEW CONTROL STRUCTURES

Construct three control structures (11,100 l.ft this sheet).

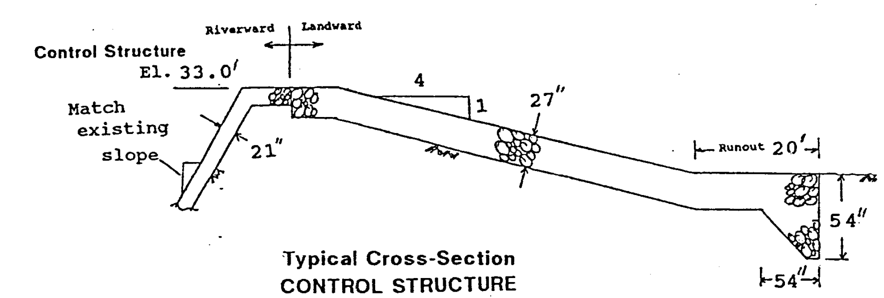
2 3 4

EXISTING BANKSIDE LEVEE

Upgrade existing bankside levee (This sheet, 30,500 l.ft. rightbank; 37,500 l.ft. leftbank.)

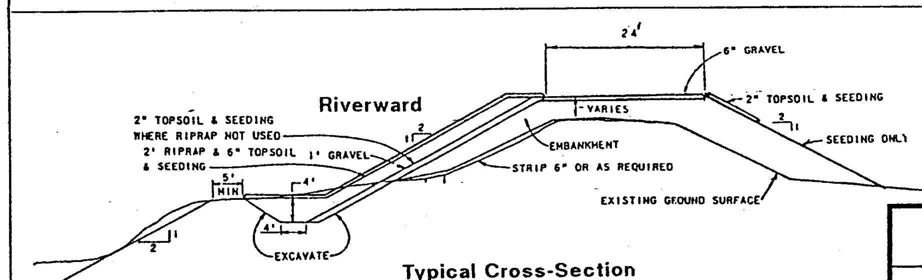


Typical Cross-Section
OFF RIVER LEVEE



Typical Cross-Section
CONTROL STRUCTURE

Dimensions and overflow elevations vary with location.



Typical Cross-Section
BANKSIDE LEVEE

SCALE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

Skagit River, Washington
Flood Damage Reduction Study
PLAN AND CROSS-SECTIONS

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
DSGN. RM, NS	CHK. JG		19 Apr 93	3

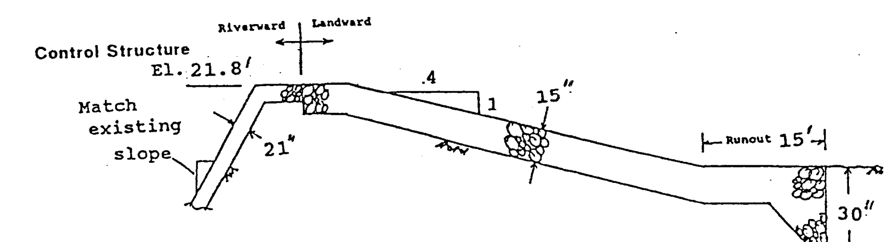
PLAN ELEMENTS

NEW CONTROL STRUCTURE

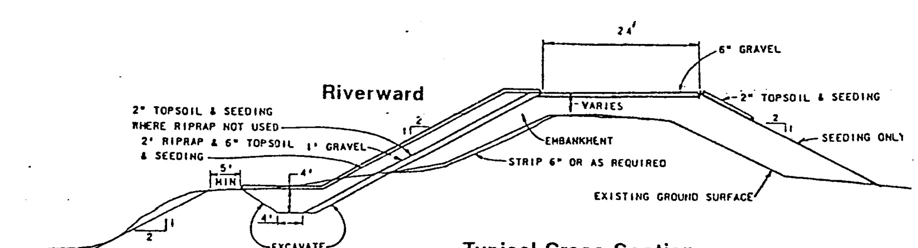
(5) Construct a 6,000-foot-long control structure in the northern alinement of the existing Fir Island levee.

EXISTING BANKSIDE LEVEE

Upgrade existing bankside levee for both the mainland and Fir Island.
(This Sheet. MAINLAND LEVEE: 42,000 l.ft South Fork; 17,000 l.ft North Fork.
FIR ISLAND LEVEE: 34,000 l.ft South Fork; 27,000 l.ft. North Fork.)
(This sheet, 59,000 linear feet mainland levee upgrade; 61,000 l.ft. Fir Island levee upgrade.)



Cross-Section
CONTROL STRUCTURE



Typical Cross-Section
BANKSIDE LEVEE

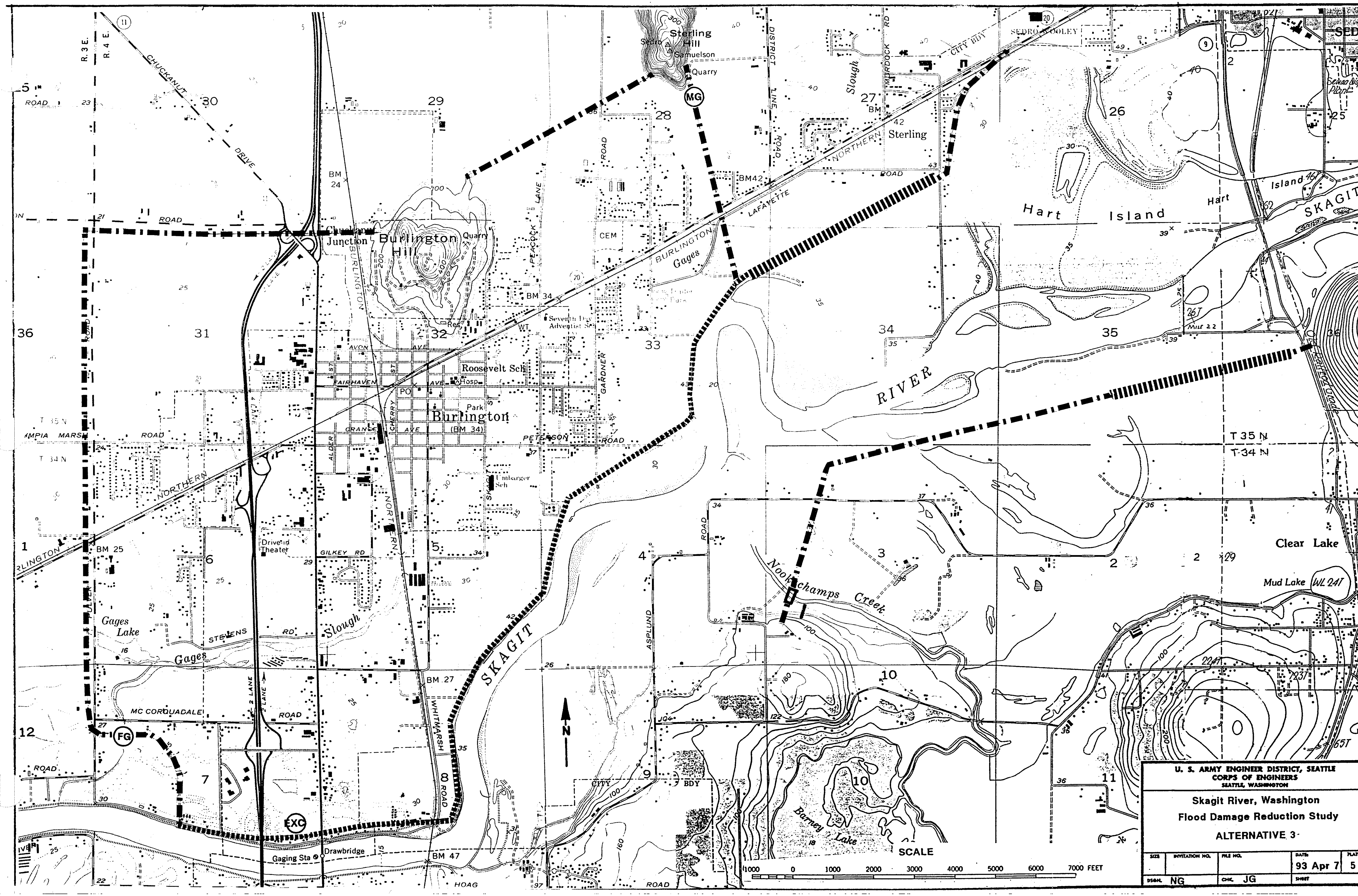
SCALE

1000 0 5000 FEET

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

Skagit River, Washington
Flood Damage Reduction Study
PLAN AND CROSS-SECTIONS

SIZE	INVITATION NO.	FILE NO.	DATE: 19 Apr 93	PLATE 4
DSGN. RM, NS		CHK. JG	SHEET	


U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
Skagit River, Washington
Flood Damage Reduction Study
ALTERNATIVE 3
DATE 93 Apr 7
PLATE 5
DSGN. NG
CHK. JG
SCALE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
Sterling Hill
Sedro
Samuelson
Quarry
MG
FG
EXC
Burlington Hill
Burlington
Junction
Sterling
Hart Island
SKAGIT RIVER
SKAGIT
RIVER
Clear Lake
Mud Lake
Gages Lake
Gages Slough
Nookachamps Creek
Barney Lake
Roosevelt Sch
Umbarger Sch
Seventh Day Adventist Sch
Drive in Theater
Gaging Sta
Drawbridge
CEM
BURLINGTON NORTHERN
CHUCKANUT DRIVE
SEDRO WOOLLEY
CITY BDY
T 35 N
T 34 N
R. 3 E.
R. 4 E.
MC CORQUADALE ROAD
STEVENS RD
GILKEY RD
PETERSON ROAD
WHITMARSH ROAD
ASPLUND
PEACOCK LANE
GARDNER
DISTRICT LINE ROAD
MURDOCK RD
LAFAYETTE ROAD
HOAG
N

APPENDIX 1

SPONSOR CORRESPONDENCE

City of Mount Vernon
Engineering Department
Post Office Box 809
1003 Cleveland Avenue
Mount Vernon, Washington 98273 • Telephone 336-6204

September 22, 1988

Colonel Phillip L. Hall
District Engineer, Seattle
Post Office Box C-3755
Seattle, Washington 98124-2255

Dear Colonel Hall:

The City of Mount Vernon requests that the U.S. Army Corps of Engineers reactivate the Skagit Flood Control Project. The City is interested in sponsoring that portion of the authorized project which would protect Mount Vernon. The City is also interested in determining if a smaller separate project could be developed to protect Mount Vernon.

We believe the potential for flooding and nature damage within the City is high. In addition the impending expiration of the congressional authorization for the project is of concern to us. We are interested in finding a solution to our flooding problems which would be acceptable to property owners.

During recent discussion with members of your staff, we understand a reconnaissance study will first be completed at the Corps expense. The reconnaissance study will determine whether or not further studies are appropriate. We also understand that if the Corps and City decide to proceed with further studies or construction, we will have to share the costs in accordance with the Water Resource Development Act of 1986 (Public Law 9-662).

Your consideration of this request would be appreciated. Please contact John Wiseman, City Engineer at 336-6204 for further information.

Sincerely,

Raymond T. Reep, Jr.

Raymond T. Reep, Jr.
Mayor

[illegible] VAUX
[illegible] DISTRICT
[illegible] WYLIE
SECOND DISTRICT
DAVE ROHRER
THIRD DISTRICT

SKAGIT COUNTY

BOARD OF COMMISSIONERS
Post Office Box 459
Mount Vernon, Washington 98273
(206) 336-9300

December 28, 1990

Milton Hunter
Colonel, Corps of Engineers
Post Office Box C-3755
Seattle, Washington 98124-2255

Dear Colonel Hunter:

This is in response to the recent flooding in Skagit County and discussions with your staff concerning a long-term solution to our flood problems.

We are interested in renewing a study to increase the flood protection for Skagit County. Unless we upgrade the level of protection, our system will continue to be vulnerable against the larger floods. Accordingly, Skagit County requests to the U.S. Army Corps of Engineers to conduct a reconnaissance study of all of the viable alternatives with a recommendation as to the positive and negative aspects of the alternatives, and which one would be the most feasible.

County representatives have discussed this study with representatives of the city and Corps. Our interest is to insure that the flood threat to unincorporated areas of the county is given consideration at the same time as study of flood protection for Mount Vernon. The county understands the requirements by law for study cost sharing and is willing to enter into a cost sharing agreement with the Corps for follow-on feasibility studies. We also understand that the Corps will first conduct a reconnaissance study at Federal expense to establish the scope and cost of feasibility studies.

We request your consideration of our interest and that you keep us informed of your progress toward initiating this study. Please work with Mr. Don Nelson and Dave Brookings of my staff to plan this study effort.

Sincerely,

Board of County Commissioners
Skagit County, Washington

W.W. Vaux

W.W. Vaux, Commissioner

Ruth Wylie

Ruth Wylie, Commissioner

Robby Robinson

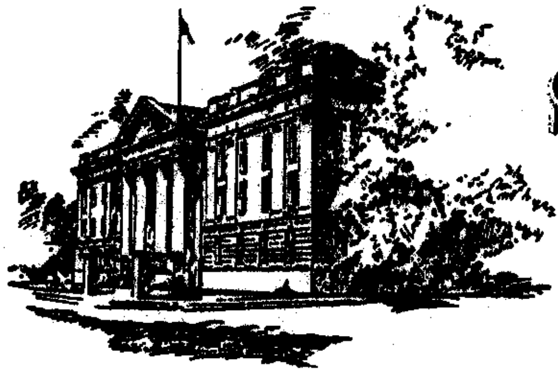
Robbie Robinson, Commissioner

WWV:RW:RR/sld

ROBERT HART
FIRST DISTRICT

HARVEY WOLDEN
SECOND DISTRICT

ROBBY ROBINSON
THIRD DISTRICT



SKAGIT COUNTY

BOARD OF COMMISSIONERS
Skagit County Administration Building
700 S. Second, Room 202
Mount Vernon, Washington 98273
(206) 336-9300
FAX# (206) 336-9307

April 15, 1993

Noel L. Gilbrough, P.E., Study Manager
P.O. Box 3755
4735 E. Marginal Way S.
Seattle, WA 98124-2255

Dear Mr. Gilbrough:

Thank you for the opportunity to comment on the draft Skagit River Reconnaissance Study. We have chosen to defer the fine tuning of the wording contained in individual sections of the document to our Flood Control Engineer, Dave Brookings; however, we do have comments on the draft on a conceptual level.

Following your report to the Board on Monday morning, we were very encouraged by the progress that has been made. It appears at this point that a feasible alternative has been chosen, and that the funding scenario suggested will be affordable. Although there are some questions still left to be answered, the information provided to date appears to support the alternative of overtopping weirs and setback levees.

We strongly support the notion of river modeling and topographic mapping as a tool for continuing to evaluate feasibility. We fear that without these two components we will be unable to make an informed decision about the level of and location of flood protection that is being planned.

At this point, we support continuing to the next phase of the study, and look forward to future progress reports.

BOARD OF COUNTY COMMISSIONERS
SKAGIT COUNTY, WASHINGTON

Robert Hart
Robert Hart, Chairman

Harvey Wolden
Harvey Wolden, Commissioner

Robby Robinson
Robby Robinson, Commissioner

APPENDIX 2

HYDRAULICS

APPENDIX 2

HYDRAULICS

1. Scope.

The scope of this work was to develop a reconnaissance level numerical model that would simulate the time variant flow and stage characteristics along the Lower Skagit River. Utilizing this model numerous flood reduction alternatives would be screened to determine beneficial versus non-beneficial alternatives.

2. Computer Program.

The UNET computer program used in this study was developed and supported through the Hydrologic Engineering Center. The unsteady flow numerical model solves the one-dimensional St. Venant equations using a weighted four point finite difference scheme. The UNET program computes profiles upstream to downstream. The basic data requirements for the program are river/valley geometric data, an upstream flow hydrograph and either a downstream flow or stage hydrograph. From these data inputs flow and stage hydrographs are computed for any cross section in the system. Additional information on the program can be found in "UNET One Dimensional Unsteady Flow Through a Full Network of Open Channels" users manual from the Hydrologic Engineering Center.

3. Basic Data

The lower 22 miles of the Skagit River from Sedro Woolley to the mouth was modeled. There were 27 cross-sections for the main stem, 20 for the North Fork, and 12 for the South Fork. The cross-sections were surveyed in 1975. No attempt was made to verify the cross-sections to present-day conditions for this study. These cross-sections were arranged in reverse HEC-2 order for the unsteady flow analysis. The upstream and downstream boundary flow and stage data used were developed by Hydrology Section. Local inflows were neglected.

4. <u>Verification Run</u>

Model adjustment was performed to the verify the observed 1975 flood event water surface elevations. This high water event was contained to the channel and numerous high water marks are available. The downstream boundary condition used the observed tide record for the vicinity of the Skagit River. The discharge hydrograph at Sedro Woolley, developed from hydrologic routing methods between Concrete and Sedro Woolley was used as the upstream boundary condition. The difference between the predicted and observed stages ranged from 0.00 to 0.60 feet with the majority of the difference on the order of 0.5 feet. Mannings roughness values used in the model were based on simulation of the 1975 observed high water data and ranged from about 0.025 to 0.035.

5. <u>Flood Reduction Alternatives</u>

The flood reduction alternatives chosen to be examined during the study were:

a. No change, existing condition

b. Samish-1 Bypass beginning downstream of Sedro Woolley (not discussed in Reconnaissance Report).

c. Samish-2 Bypass beginning downstream of Interstate 5 (Alternative 1).

d. Urban Levees (100 year) with rural levees and control structures (25 year) (Alternative 2 - Selected Alternative).

6. Description of Flood Reduction Alternatives

6.1 Existing Conditions

The existing condition was developed to estimate without project damages. Using the existing condition a probable failure point-probable non-failure point (PFP-PNP) analysis was conducted to determine levee failure/non failure discharges.

6.1.1 PNP-PFP Analysis

A PFP-PNP analysis was performed to determine the level of protection of the present levee system. The study area was divided into 10 subareas. A geotechnical evaluation of the levee system determined 29 different levee sections each with a distinct PFP-PNP point. The model was coded so each levee failed at the required PFP-PNP stage. For each levee section the output was analyzed to determine the discharge that resulted in levee failure/non failure. This analysis was conducted for the entire length of the existing levee system and for both the PFP and PNP levee points. Sequencing of levee failures and downstream effects have not been addressed in this reconnaissance level of study.

Future studies will need to determine the sequence of levee failures and downstream effects. The discharges were then regionally analyzed to determine the minimum discharge that would result in levee failure for each subarea. No allowance for flood fighting was built into the model.

PFP/PNP Discharge and Frequency Results

Subarea	PNP Discharge (x1,000 cfs)	Return Frequency (yr)	PFP Discharge (x1,000 cfs)	Return Frequency (yr)
1	145	24.4	145	24.4
2	138	20.0	138	20.0
3	138	20.0	138	20.0
4	117	10.5	117	10.5
5	138	20.0	144	23.8
6	117	10.5	117	10.5
7	117	10.5	117	10.5
8	133	16.7	144	23.8
9	145	24.4	145	24.4

6.2 Samish-1 Bypass Alternative (not discussed in Reconnaissance Report in detail).

The Samish-1 Bypass alternative would divert a maximum 80,000 cubic feet per second (cfs) out of the Skagit River from the upper reaches of the study area into the Samish River by means of a lateral overflow weir diversion structure and shallow earthen canal. Removing 80,000 cfs from the system during a 100 year event would keep the

The diversion structure as designed is 1300 feet wide and 100 feet long. The overflow sill is at El 36 for a maximum discharge of 80,000 cfs. At this elevation, overflow will begin at a 5 year event. The outlet structure also includes a stilling basin and outlet channel to reduce energy. The structure was designed using guidance in EM 1110-2-1605.

6.2.2 Bypass Channel

The bypass channel was designed to convey 80,000 cfs from the Skagit River to Samish Bay. A HEC-2 model using existing topographic maps was used to size the bypass channel. The final design resulted in a channel 11.5 miles long, approximately 2200 feet wide and 8-10 feet deep. The channel was designed with a low flow section to carry frequent low discharges. The maximum velocity in the bypass channel would be less than 4 feet per second (fps).

The bypass channel would need 4 new bridge structures constructed. These bridge openings were all modeled using HEC-2 bridge routines. It is assumed that for this alternative all secondary roads crossed by the bypass channel would be lowered to the channel invert elevation.

A maximum tide of 6 ft NGVD and a constant 80,000 cfs hydrograph were used for the boundary conditions. Shoaling that could occur at the mouth of the bypass channel was not coded into the model. If future studies determine that shoaling might occur, redesign of the final 2-3 miles of the bypass channel will be required. It is assumed that the bypass channel would be lined with short grazing grasses and little or no shrubs.

6.2.3 Levee System

The existing levee system along the Skagit River was redesigned for with-project conditions. The outlet structure removed 80,000 cfs from the system during a 100 year event. New levees were inserted in the model from the outlet structure to the existing levee system on the right bank. The Nookachamps area was modeled as a storage area.

A simplified uncertainty based approach was conducted to determine with project levee elevations. Uncertainty in Manning 'n', bridge openings and sedimentation were estimated and coded into the model.

The urban areas were designed for 100 year protection while the rural areas would have 50 year protection. The urban areas extended from RM 12.4 on the main stem to the upstream limits of the levee system on the right bank and from RM 12.4 on the main stem to the Burlington Northern Railroad Bridge on the left bank. The rural areas extended from RM 12.4 to the confluence on the main stem and along both the North and South Forks.

Using the numerical model, with the hydraulic uncertainty, the 50 and 100 year hydrographs were routed through the system. Using the output from these runs the maximum calculated WSEL for the urban and rural areas was used as guidance for the with-project design levee elevations.

Superelevation was added to five areas per the 1979 Skagit River General Design Memorandum (GDM). The design levee elevation was adjusted in these 5 areas.

6.3 Samish-2 Bypass Alternative (Alternative 1)

The Samish-2 bypass is designed to withdraw a maximum 80,000 cfs from the Skagit River system downstream of the Interstate 5 bridge and combine with the Samish River. The diversion structure is located between RM 16.30 and 16.60 on the right bank of the Skagit River.

6.3.1 Diversion Structure

The diversion structure as designed is 1200 feet wide and 100 feet long. The overflow sill is at El 32 resulting in a maximum discharge of 80,000 cfs. At this elevation overflow would begin at a 5 year event. The diversion structure contains a stilling basin and outlet channel to reduce the water's energy. The diversion structure was designed using guidance in EM 1110-2-1605.

6.3.2 Bypass Channel

The bypass channel is designed to divert a maximum 80,000 cfs from the Skagit River into Samish Bay. A HEC-2 numerical model using existing topographic maps was constructed to design the bypass channel. The selected final design of the channel resulted in a channel 8.5 miles long, approximately 2100 feet wide and 7-10 feet deep. The channel was designed with a low flow section to carry frequent low discharges. The diversion structure starts operating at a 5 year event. The velocity in the bypass channel would be below 4 fps.

A maximum tide of 6 feet and a constant 80,000 cfs hydrograph were used for the boundary conditions. Shoaling that could occur at the mouth of the bypass channel was not coded into the model. If future studies indicate that shoaling might occur, redesign of the final 2-3 miles of the bypass channel would be required. It is assumed that the bypass channel would be lined with short grasses and no or very little brush.

The Samish-2 bypass channel would require 1 new bridge structure to be constructed where Highway 20 and Burlington Northern Railroad cross the bypass channel approximately 1 mile downstream of the diversion structure. It is assumed that for this alternative all roads that the bypass channel crosses would be lowered to the channel invert elevation.

6.3.3 Levee System

The existing Skagit River levee system for with-project conditions was redesigned. The bypass discharge of 80,000 cfs was removed from the system between RM 16.30 and RM 16.60. New levees were inserted in the model from the existing levees on the right bank upstream to RM 22.40. This is to contain the Skagit River within existing banks. The Nookachamps area was modeled as a storage area.

A simplified uncertainty approach was conducted to determine with project levee elevations. Uncertainty in Manning 'n', bridge openings and sedimentation were determined and coded into the model.

The urban area was designed for 100 year protection while the rural areas would have 50 year protection. The urban level of protection extended from RM 12.4 on the main stem to the upstream limits of the levee system on the right bank and from RM 12.4 on the main stem to the Burlington Northern Railroad Bridge on the left bank. The rural level of protection extended from RM 12.4 to the confluence on the main stem and along both the North and South Forks.

Using the numerical model and the simplified hydraulic uncertainty approach the 50 and 100 year hydrographs were routed through the system. Using the output from these runs the maximum calculated WSEL for the urban and rural areas was used as guidance for the with project design levee elevations.

Superelevation was added to five areas per the 1979 GDM. The design levee elevation was adjusted in these 5 areas.

6.3.4 Redesign of Existing Bridges

The Samish-2 Bypass requires routing the entire 100 year discharge of the Skagit River through three existing bridges structures (RM 17.55 to RM 16.80). Due to channel and bridge characteristics it is probable that the 100 year event would overtop these bridges. To prevent bridge overtopping each of the bridges were modified as follows:

a. Burlington Northern Bridge (RM 17.55).

- Removal of the gravel bar on the right bank with excavation down to El 5 extending to the existing levee location.

- Increase channel width by 200 feet on the right bank.

b. Highway 99 Bridge (RM 17.05).

- Increase channel width by 200 feet on either the left or right bank.

c. <u>Interstate 5 Bridge (RM 16.00)</u>.

- The channel width was increased by 150 feet.

d. <u>Channel downstream of the I-5 Bridge</u>.

- Channel widened by 150 feet to the downstream end of the diversion structure.

e. <u>Channel upstream of the BN Railroad Bridge</u>.

- Channel widened by 100 feet.

6.4 Urban Levees (100 year) with rural levees with control structures (25 year) - Alternative 2 (Selected Alternative)

Overflow levee sections (control structures) were designed to withdraw a total of 80,000 cfs from the system during a 100 year event. The overflow sections were placed to minimize impacts on present developments and to direct the discharge to the rural areas. Five sites were selected by Skagit County Commissioners and the project manager to contain the overflow sections. The sites and hydraulic properties of the overflow sections are listed below.

Overflow Location	Width of Overflow	Height of Weir (ft)	Area Flooded
1. Sterling	5,000 ft	42.0-42.2	21 sq.mi.
2. Gages Slough	3,700 ft	37.6-38.1	21 sq.mi.
3. Memorial Hwy	4,200 ft	32.2-33.8	24 sq.mi.
4. Britt Slough	3,200 ft	26.2	11 sq.mi.
5. Fir Island	6,000 ft	21.5-22.0	11 sq.mi.

These overflow sections will reduce the discharge at the confluence of the North and South Forks of the Skagit River to 155,000 cfs. The overflow levee system will not start to overtop until the discharge reaches 155,000 cfs. At 155,000 cfs all overflow sections will begin overtopping within 1-2 hours.

6.4.1 Control Structure Design

The overflow sections consist of a rip-rapped slope design based on results of a previous physical model test at WES (TR 2-650, June 1964, "Stability of Riprap and Discharge Characteristics, Overflow Embankments, Arkansas River, Arkansas"). Riprap was designed to prevent failure of the overflow section during the 100 year event. The riprap selection and hydraulic properties for the overflow sections are listed below.

Section Number	Riprap Thickness (in)		Max Riprap Diameter (in)		Overflow Levee EL (ft, NGVD)	Runout Length (ft)	Width of Overflow (ft)
	t_1	t_2	d_1	d_2			
1	21	36	16	24	42.1	25	5000
2	21	27	16	18	37.8	20	3700
3	21	27	16	18	33.0	20	4200
4	21	15	16	14	26.3	15	3200
5	21	15	16	14	21.8	15	6000

where:

t_1 riprap thickness, riverward side of levee
t_2 riprap thickness, landward side of levee
d_1 riprap diameter, riverward side of levee
d_2 riprap diameter, landward side of levee

6.4.2 Ring Dikes (urban levees)

The location of the overflow levees could result in water entering the cities of Burlington, Mount Vernon and West Mount Vernon. Ring dikes were designed to protect these areas up to a 100 year event. The location of the dikes are shown on plates 2 and 3. The height of the ring dikes were determined by narrowing the flood plain and increasing the 'n' value to describe a worst case scenario. The design height of the dikes are:

Location	Height (ft)
Burlington	4.0-5.1
West Mount Vernon	4.5
South Mount Vernon	4.5
Mount Vernon	match existing

The ring diked areas will be required to have pumps, culverts and flap gates installed to remove rainwater and small creek/slough flow. The pumps were sized to pump the 100 year - 72 hour rainfall volume. The culverts and flapgates were sized to match existing structures.

6.4.3 Levee System (Urban and Rural

The existing levee system along the Skagit River was redesigned for with project conditions. The overflow levee sections removed a maximum 80,000 cfs from the system during a 100 year event. New levees were inserted in the model on the right bank from Sedro Woolley to the first overflow weir. The Nookachamps area was modeled as a storage area.

A simplified uncertainty approach was conducted to determine with project levee elevations. Uncertainty in Manning 'n', bridge openings and sedimentation were determined and coded into the model.

The urban areas were designed for 100 year protection while the rural areas have 25 year protection. These levees extended from RM 12.4 on the main stem to the upstream limits of the levee system on the right bank and from RM 12.4 on the main stem to the Burlington Northern Railroad Bridge on the left bank. This rural level of protection extended from RM 12.4 to the confluence on the main stem and along both the North and South Forks.

Using the numerical model, with the simplified hydraulic uncertainties, the 100 year hydrograph was routed through the system. Using the output from these runs the maximum calculated WSEL for the urban and rural areas was used as guidance for the with-project design levee elevations.

Superelevation was added to five areas per the 1979 GDM. The design levee elevation was adjusted in these 5 areas.

7. Final Results

The final levels of protection for the three different alternatives studied are:

Level of Protection for the Skagit River Flood Plain
Levels of Protection (years)
Overflow

Sub-Area[1]	Existing PNP	Existing PFP	Levee Sections	Samish Bypass	Padilla Bypass
1	25.6	25.6	100	100	100
2	20.0	20.0	25	100	100
3	20.0	20.0	25	50	50
4	10.5	10.5	100	100	100
5	20.0	25.0	100	100	100
6	10.5	10.5	100	100	100
7	10.5	10.5	25	50	50
8	16.7	25.0	25	50	50
9	25.6	25.6	25	100	100

1 See figure 1, Reconnaissance Report

8. <u>Future Studies</u>

The hydraulic studies accomplished to date are not considered adequate for use beyond the reconnaissance levee of study. Significant refinement of the UNET unsteady flow model using additional and up-to-date channel geometry is necessary. Considerable effort is needed to ensure that levee overtopping conditions are adequately simulated. Limited use of the model in attempting to simulate the Fir Island levee break during the 1990 flood indicated problems with the existing model which need to be resolved for feasibility studies. Hydraulic roughness needs to be better determined for both design conditions and for use in hydraulic uncertainty analysis. Sequencing of levee failures and downstream effects need to be determined for existing conditions.

Design of the overtopping levee sections requires significantly more detailed studies for feasibility level to develop the most cost effective, safe design. Physical model studies may be necessary in arriving at such a design.

Determination of hydraulic conditions in the near vicinity of the overtopping sections and simulations of how progressive flooding affects conditions may require the use of a two dimensional model.

APPENDIX 3

COST ENGINEERING REPORT

TABLE 1

SUMMARY OF PROJECT COST ESTIMATE
(October 1993 Price Level)

FEDERAL & NON-FEDERAL COSTS

ACCOUNT NO.	FEATURE	COST	CONTINGENCY (25%)	AMOUNT
06	Fish & Wildlife (6%)	$1,400,000	$400,000	$1,800,000
11	Levees and Floodwall			
	A. Region I: Burlington	$15,800,000	$4,000,000	$19,800,000
	B. Region II: Mt. Vernon	$7,500,000	$1,900,000	$9,400,000
	C. Region III: Sedro Woolley	$300,000	$100,000	$400,000
14	Cultural Resources (1.5%)	$400,000	$100,000	$500,000
	SUBTOTAL	$25,400,000	$6,500,000	$31,900,000
01	Lands & Damages	$10,000,000	$2,000,000	$12,000,000
30	Engineering and Design (10%)	$2,500,000	$600,000	$3,100,000
31	Supervision and Administration (7%)	$1,800,000	$500,000	$2,300,000
	TOTAL PROJECT COST:	$39,700,000	$9,600,000	$49,300,000
	Maintenance / year			$295,000

REGION I: BURLINGTON AREA

Feature or Item	Unit	Quantity	Price	Amount
A. DIKES -				
1. Clearing	Acre	5.2	3000	15,600
2. Stripping (12 in.)	SY	33500	1.2	40,200
3. Embankment from Excav.	CY	124000	4	496,000
4. Gravel	CY	14800	9	133,200
5. Topsoil	CY	9600	16	153,600
6. Seeding	SY	86500	0.4	34,600
B. CULVERT (CMP)				
1. 18"	LF	660	9	5,940
2. 24"	LF	200	16	3,200
3. 36"	LF	180	32	5,760
C. FLAPGATE				
1. 18"	EA	6	1900	11,400
2. 24"	EA	4	2100	8,400
3. 36"	EA	1	2700	2,700
D. GDM LEVEES -				
1. Clearing	ACRE	3	3000	9,000
2. Stripping	CY	22500	1.2	27,000
3. Embankment from Excav.	CY	168000	4	672,000
4. Gravel	CY	22600	9	203,400
5. Topsoil	CY	7400	16	118,400
6. Seeding	SY	92500	0.4	37,000
E. PUMPS -				
1. 30 cfs	EA	3	23000	69,000
2. 100 cfs	EA	4	121000	484,000
3. Truck mounted manhole	EA	3	15000	45,000
F. OVERFLOW LEVEE RIPRAP				
1. Riprap	CY	70500	24	1,692,000
2. Quarry Spalls	CY	21200	20	424,000
G. ACCESS RAMPS	EA	36	2500	90,000
H. ROAD CROSSING	EA	6		
1. 2" A.C. pavement	SY	6540	7	45,780
2. Gravel, road base	CY	3480	10	34,800
3. Bituminous Surface Treatment	SY	6540	1	6,540
I. PAVED ROAD	SY	440	7	3,080
J. RELOCATED BUILDINGS	EA	31	22000	682,000
K. 20' SHEET PILE WALL	LF	120	300	36,000
L. GAUGES SLOUGH				
1. Screw gate	EA	1	2500	2,500
2. Flapgate	EA	1	2100	2,100

M.	RIVER WIDENING				
	1. Excavate to embankment Burlington/Mt. Vernon	CY	1500000	4	6,000,000
N.	MISCELLANEOUS				
	1. RELOCATE CO. RD.	MI	2		
	a. 2" A.C. pavement	SY	35200	7	246,400
	b. Gravel, road base	CY	3920	10	39,200
	c. Bituminous Surface Treatment	SY	35200	1	35,200
	2. I-5 BRIDGE	LS	1	50000	50,000
	3. RAILROAD BRIDGE	SF	22500	110	2,475,000
	4. HWY 99 BRIDGE	SF	12000	110	1,320,000
	5. UTILITY CROSSING	LS	1	5000	5,000
	6. PROTECTION OF WELL	EA	1	10000	10,000
				TOTAL	=$15,775,000
	MAINTENANCE/YEAR	MI	25	5000	125,000

REGION II: MOUNT VERNON AREA

Feature or Item	Unit	Quantity	Price	Amount
A. DIKES -				
1. Clearing	Acre	2.2	3000	6,600
2. Stripping (12 in.)	SY	22000	1.2	26,400
3. Embankment from Excav.	CY	229000	4	916,000
4. Gravel	CY	9600	9	86,400
5. Topsoil	CY	7300	16	116,800
6. Seeding	SY	77700	0.4	31,080
B. CULVERT (CMP)				
1. 18"	LF	380	9	3,420
2. 24"	LF	100	16	1,600
3. 36"	LF	120	32	3,840
C. FLAPGATE				
1. 18"	EA	6	1900	11,400
2. 24"	EA	2	2100	4,200
3. 36"	EA	1	2700	2,700
D. GDM LEVEES -				
1. Clearing	ACRE	4	3000	12,000
2. Stripping	CY	30300	1.2	36,360
3. Embankment from Excav.	CY	176000	4	704,000
4. Gravel	CY	35900	9	323,100
5. Topsoil	CY	8900	16	142,400
6. Seeding	SY	111000	0.4	44,400
E. PUMPS -				
1. 15 cfs	EA	2	17500	35,000
2. 30 cfs	EA	3	23000	69,000
F. OVERFLOW LEVEE				
1. Riprap	CY	67000	22	1,474,000
2. Quarry Spalls	CY	20100	18	361,800
G. ACCESS RAMPS	EA	45	2500	112,500
H. ROAD CROSSING	EA	15		
1. 2" A.C. pavement	SY	16400	7	114,800
2. Gravel, road base	CY	8700	10	87,000
3. Bituminous Surface Treatment	SY	16400	1	16,400
I. TILT-UP FLOODWALL	SF	6900	35	241,500
J. PAVED ROAD	SY	1100	7	7,700
K. RELOCATED BUILDINGS	EA	50	22000	1,100,000
L. MISCELLANEOUS				
1. RELOCATE CO. RD.	MI	2		
a. 2" A.C. pavement	SY	35200	7	246,400
b. Gravel, road base	CY	3920	10	39,200

c. Bituminous Surface Treatment	SY	35200	1	35,200
5. UTILITY CROSSING	EA	1	5000	5,000
6. MT. VERNON BRIDGE	SF	4000	110	440,000
7. SEWAGE TREATMENT PLANT	EA	1	50000	50,000
8. FIR ISLAND TIDE GATES	LS	1	500000	500,000
9. N & S FORK LEVEES Embank. from Excav.	CY	10000	4	40,000
10. STANWOOD CROSS LEVEE	LS	1	50000	50,000
11. PROTECTION OF WELL	EA	1	10000	10,000
			TOTAL =	$7,508,200
MAINTENANCE/YEAR	MI	30	5000	150,000

REGION III: SEDRO WOOLLEY AREA

Feature or Item	Unit	Quantity	Price	Amount
A. DIKES -				
1. Clearing	Acre	0	3000	0
2. Stripping	SY	1700	1.2	2,040
3. Embankment from Excav.	CY	37200	4	148,800
4. Gravel	CY	600	10	6,000
5. Topsoil	CY	800	14	11,200
6. Seeding	SY	9600	0.4	3,840
B. CULVERT (CMP) -				
1. 18"	LF	100	9	900
C. FLAPGATES -				
1. 18"	EA	2	1900	3,800
D. ACCESS RAMPS	EA	6	2500	15,000
E. ROAD CROSSING	EA	5		
1. 2" A.C. pavement	SY	5500	7	38,500
2. Gravel, road base	CY	2900	10	29,000
3. Bituminous Surface Treatment	SY	5500	1	5,500
F. PAVED ROAD	SY	400	7	2,800
G. RELOCATED BUILDINGS	EA	1	22000	22,000
H. MISCELLANEOUS				
1. UTILITY CROSSING	EA	1	2000	2,000
			TOTAL =	$291,380
MAINTENANCE/YEAR	MI	4	5000	20,000

APPENDIX 4

REAL ESTATE REPORT

Real Estate for Alternative No. 2 - Urban Flood Control and Overflow Levees in Rural Areas

It is currently estimated that approximately 445 acres of land would be needed to suppoort Alternative Number 2. There are approximately 757 ownerships involved. Land usages include irrigated/agricultural, residential, and commercial. The real estate requirements and cost for the proposed project is summarized below.

a. Public Law 91-646 Relocation Benefits. It is currently estimated that there may be 26 residential relocations, 36 tenant relocations and 15 business relocations as a result of Alternative Number 2. Relocation benefit costs at this time are estimated to be $1,276,000, not including Local Sponsor and Federal administrative costs.

b. Relocations. Road relocations are anticipated to be necessary in Region I, Burlington Area for the river widening portion of the project; and Region II, Mount Vernon Area along a portion of the main stream, and the North and South Forks of the Skagit River.

c. Mitigation. The precise method of mitigation for this project is undetermined at this time. As the type and amount of mitigation are decided during the feasibility phase of the study the need and extent of additional lands, easements and rights-of-way will be determined.

d. Estates. The proposed estates to support Alternative Number 2 consist of permanent flood protection levee easements; channel improvement and flowage easements; road easements; drainage ditch easements; and utility and/or pipeline easements. If mitigation of fish and wildlife and cultural resource losses are determines as necessary a fee estate for mitigation lands is required. Temporary easements are needed for the temporary work areas, disposal area, for excavated material from the river widening portion of the project, and temporary access easements for ingress and egress during construction.

e. Initial Real Estate Cost Estimate. The real estate cost estimate of $10,000,000 plus 2,000,000 contingency for Alternative Number 2 includes an estimate for lands and damages (including land needed for road and potential utility and/or pipeline relocations); Public Law 91-646 relocation benefits; and both Federal and Non-Federal administrative costs for acquisition of lands, easements and rights-of-way.

The estimated cost and acreage provided does not take into consideration the consequence of a court ruling on a pending federal district court law suit, Halverson, et al v. Skagit County et al, filed by individuals representing all persons who resided in, or who own property and/or business in the Nookachamps, Sterling Hill, Lafeyette Road and Clear Lake locality, (the "Inundated Communities"). In September 1992, plaintiffs filed a suit against Skagit County, and Diking Districts No. 17 and 12 in U.S. District Court for the Western District of Washington. Plaintiffs seek redress from the County and two diking districts for unconstitutionally taking plaintiffs' property without compensation by intentionally diverting water from the Skagit River onto plaintiffs' land, thereby using plaintiffs' properties as a storage basin for additional and unnatural amounts of water. Two types of relief are being sought by the plaintiffs, monetary relief and equitable relief. Relief is sought for (1) the "taking" of plaintiffs' property by intentially diverting water from the Skagit River onto plaintiffs' land, thereby causing a diminution in market value of their properties by the public use of their private properties by defendants' opreration of the diking system; (2) for damages incurred during the 1990 inundation of their property by water diverted from the Skagit River; (3) to enjoin future actions of defendants that could increase the likelihood of inducted flooding on plaintiffs' properties; and (4) injunctive relief requiring defendants to ameliorate some of the induced flooding that will impact the Inundated Communities.

APPENDIX 5

FISH & WILDLIFE REPORT

INTRODUCTION

The Corps has undertaken this reconnaissance level study under the authority of the Puget Sound and Adjacent Waters Comprehensive Water and Related Land Resource Study from the Flood Control Act of 1962, Public Law 87-874, Section 209. This planning aid report provides a reconnaissance level description of the fish and wildlife resources of the Skagit River basin study area and of potential project related impacts to those resources. It also provides recommendations to assist the Corps in avoiding or mitigating potentially adverse impacts. The purpose of the reconnaissance study is to comprehensively examine multiple alternatives for flood damage reduction for further feasibility studies. The Corps, agency staff members, and members of the public initially identified roughly eight flood damage reduction alternatives. They include:

1. A cut-off levee to protect Stanwood from the South Fork Skagit River.

2. Relocation of the waterfowl feeding area on the island between Freshwater and Steamboat Sloughs so that the levee at the upstream end can be breached and the island allowed to flood.

3. Development of set back levees on the Fir Island side of the North Fork of the Skagit River, including a trestle on the island side bridge abutment.

4. Placing the west approach to the Division Street bridge in Mount Vernon on a trestle to reduce that bottleneck effect.

5. Development of a variation of the Avon bypass concept, now considering routes to Samish Bay and entrance points upstream of Burlington, to alleviate bottlenecks at the Burlington Northern Railroad bridge and the Highway 99 bridge.

6. Improvement of the channel capacity at the Burlington Northern Railroad and Highway 99 bridges.

7. Develop a levee to protect Clear Lake and floodproof structures in the lower Nookachamps sub-basin.

8. Develop a flood warning system for areas upstream of Sedro Woolley.

These alternatives were examined in limited detail early in the reconnaissance phase. Subsequently, the Division Street bridge alternative has become a separate Section 205 reconnaissance study. An overflow bypass to the Samish River is being investigated in greater detail, and local interests have requested the inclusion of an alternative limited to ring dikes around the Mount Vernon and Burlington urban areas accompanied by a series of overflow weirs.

This report is organized to provide general and specific coverage. The project was first described as a comprehensive study covering the lower river basin, however, a broader description of the river and its adjacent environment and resource inventory is included. The specific measures described to the Service are limited in area and scope to the lower segment of the river basin; therefore specific descriptions of project sites, resources, and potential impacts follows the general description.

PROJECT LOCATION AND DESCRIPTION

It is possible to describe the lower Skagit valley in the context of floods and flood damage reduction only by also including the lower Samish River. Before dikes and levees were constructed in either basin, Skagit floodwaters mixed with the Samish rather frequently. Most of the study area is now diked, the earliest having begun in the 1860's, and organized diking districts were formed in the late 1890's (Corps, 1979). The reconnaissance study area described by the Corps includes the lower basin and valley from south of the mouth of the South Fork of the Skagit at the dike road dividing the Skagit valley from Stanwood, north along Skagit Bay, Padilla Bay to Samish Bay and the mouth of the Samish River, up the Samish River to Interstate 5, and up the Skagit to the Highway 9 bridge near Sedro Woolley.

The lower Skagit valley is a moderately broad, flat floodplain of rich soils well suited to agriculture. Not surprisingly, that is the primary land use in the lower valley, and it includes dairy farms and flower bulbs, vegetables, seed, berries, and wheat as the major crops, with over 100,000 farmed acres county-wide (Corps, 1979). About 60,000 acres are located in the flood plain study area, not counting an additional 14,000 flood plain acres in common with the Samish River (Corps, 1979). Several cities and towns also occupy the floodplain study area. They include LaConner, Conway, Mount Vernon, Burlington, Sedro Woolley, Avon, Allen, and, to the north of the Samish River, Edison. High ground in the lower valley is limited to Bow Hill, Bayview Ridge, Pleasant Ridge, Burlington Hill, and Sterling Hill. Mount Vernon abuts the higher ground to the east and southeast that form the left bank edge of the Skagit valley.

From Highway 9 near Sedro Woolley, the Skagit River flows west toward Burlington, thence generally south. Just past Mount Vernon the river divides into its major distributaries the north and south forks. Lacking any interference, it is the nature of the lower Skagit River to braid into numerous channels and to meander across the lower valley. The north fork flows southwest to Skagit Bay at a point south of LaConner. The south fork flows almost due south, but further divides into still smaller distributaries that include Freshwater Slough, Steamboat Slough, and Tom Moore Slough. These divide still further into several minor distributaries.

The principle project alternatives are now reduced to two. The first is a flood bypass channel with a diversion located between Burlington and Sedro Woolley. The proposed channel capacity would be 80,000 cfs. The diversion would likely be located along Hart Island Slough just south of Highway 20. The preliminary route is north around Sterling Hill to Butler Flat and into the Samish River near its confluence with Thomas Creek. A channel excavated five feet deep and half a mile wide would be needed. The flood channel would then follow the course of the Samish River to Samish Bay. This channel would also have to carry the Samish River and its floodwaters. The Samish River channel and floodway would be straightened in an east-west orientation for nearly a mile in the vicinity of Chuckanut Drive in order to miss Allen. By picking up the lower Samish River, some flood damage reduction benefits might be claimed for this area also. About 50 miles of levees in the lower valley would have to also be upgraded in this alternative, but the final project would provide 100 year flood protection to the lower valley downstream of Highway 9.

The second principle alternative includes ring dikes around the urban areas of Mount Vernon and Burlington, accompanied by a series of six overflow weirs from Hart Island Slough to Fir Island. The ring dikes would provide 100 year flood protection to the urban areas, and the overflow weirs would extend 25 year protection to the rural areas. The precise locations of the features of this alternative will not be described until the feasibility study, but the general description is as follows:

The Burlington dike would leave the Skagit River near Sterling bend and stretch northerly to Sterling Hill, then to Burlington Hill, then west to I-5 and south to elementary school, then west to about Pulver Road, then south to the Skagit, then upstream to the point of origin.

The Mount Vernon dike would begin near the Burlington Northern Railroad bridge and extend west along the river to the city limits, then south to Riverbend Road, then downstream along the river through town to the sewage treatment plant, then south along Britt Slough to Blackburn Road, then east to high ground.

The overflow weirs would be located near Hart Island Slough, downstream of the Mount Vernon dike, downstream of the Burlington dike, near Memorial Highway, near the mouth of Britt Slough, and near the 1990 break at the Fir Island dike. Unspecified additional levee improvement work would also be a part of this project alternative. We understand these sites are preliminary and are described for reconnaissance study and evaluation purposes only.

FISH AND WILDLIFE RESOURCES IN THE SKAGIT RIVER BASIN

The Skagit River is the largest drainage in Puget Sound, contributing approximately one-third of its freshwater inflow. The river drains flat lowlands and foothills in the western end of Skagit County and mountainous areas including six and seven thousand feet elevation peaks in the remainder of the basin. The mainstem Skagit is 162 miles in length, including 35 miles in Canada. The watershed area is 3,093 square miles upstream of Mount Vernon, with 400 square miles in Canada (USGS, 1991). Average annual runoff exceeds 11.7 million acre-feet per year with an average discharge of 16,220 cubic feet per second at Sedro Woolley. The river drains Skagit and part of Whatcom and Snohomish Counties as well as the portion in southern British Columbia.

The Skagit has a very slight gradient, averaging less than one tenth of one percent, from its mouth to Gorge powerhouse at Newhalem. The Newhalem stream gage near River Mile 93 is at elevation 393 feet above mean sea level at average stream flow. Most of the land in the study area and the entire valley floor has been converted from its natural condition. The principle land uses are agriculture, with numerous dairy farms in the lower valley; rural residential development; small towns; and limited forestry. The stream banks of the lower river are natural sharp earth cuts through sandy silt soil or artificially contoured or riprapped dikes. A significant proportion of the study area streambank has been armored with riprap. The stream bed likewise consists of sand and silt with limited deposits of gravel downstream of Highway 9. Riparian cover is intermittent, consisting primarily of occasional thickets of deciduous trees and underbrush. The most common streamside feature is a grass covered levee.

Utilization of the lower mainstem by anadromous fish is primarily for upstream and downstream migration and juvenile rearing (Williams, 1975). Very little mainstem spawning by adult salmonids occurs downstream of the Highway 9 bridge near Sedro Woolley. The frequency of occurrence of gravel bars increases upstream of Sedro Woolley, and especially upstream of Lyman, and mainstem spawner densities also increase as one progresses upstream. Fish production in the mainstem is limited by lack of stream channel complexity, riprap, stream bank clearing and maintenance, channelization, sedimentation, and channel shifting. The last of these limiting factors is the only one resulting exclusively from natural processes. All the others are caused by or exacerbated by human development. According to information provided by the Skagit System Cooperative, flood protection measures have caused the greatest loss of juvenile salmon rearing habitat because they have effectively isolated the river from much of the floodplain (Wasserman, pers. comm.). The Skagit Coop also found that the juvenile standing crop was reduced 90% for coho and 50% for all salmonids combined along diked and protected banks of the mainstem Skagit compared to natural streambank areas.

The considerable fish and wildlife resources of the lower Samish River basin are also important to this reconnaissance level project evaluation. A general description of them is included.

AQUATIC RESOURCES

The fisheries resources of the Skagit River evolved with the basin's hydrologic cycle pretty much as it exists today, with large seasonal flow variations, from draught to flood, modified somewhat by development and operation of five major hydroelectric developments; three on the mainstem Skagit and two on the Baker River. Two of the projects, one each on the Skagit and Baker, are storage projects that alter the time of water release from the controlled portion of the basin from late spring and summer to the winter season for electrical power generation. Significant at the present and local scale, is changing land use, from old growth forests and a low average rate of change in landscape features, to agriculture, residential and urban development, and farm forestry; with their relatively rapid changes to landscape features. The rates of change commonly exceed the rates of the stabilization processes that typically accompany change. These have influenced important stream channel modifications, especially in tributaries, from a fisheries habitat perspective. Channel complexity has been reduced. Large woody debris has been removed, reducing the frequency of pools and the quantity and quality of juvenile salmon habitat. Levees have been built that reduce the channel width and reduce the width of meanders.

Biologists have identified five characteristics of viable anadromous fish habitat. They can be summarized in the following way:

* Access to and from the sea,
* An adequate supply of good quality water,
* Suitable gravel for spawning,
* Food, and
* Sufficient shelter.

These are features generally abundant but specifically lacking in the Skagit River system. Access to and from the Baker River is the significant exception; only a limited amount of known anadromous fish habitat existed upstream of two of the Skagit dams. Access is otherwise seldom or never compromised, except possibly at extreme low flows at some tributary locations. The water quality is described by the Washington State Department of Ecology as AA, its highest rating. Occasional floods scour incubating eggs from the gravel and prematurely drive juvenile salmonids to the sea when shelter is lacking. Low summer flows limit juvenile rearing habitat in tributaries but not the mainstem. Spawning gravel is abundant throughout most of the basin, but is least common in the lower mainstem, which is in the project study area, and much of that is tidally influenced. Food is usually not limiting for juvenile salmonid production, but it may affect production in the glacially influenced tributaries.

Hydrologists and stream geomorphologists indicate that changes in land use and intensive logging and road building in the watershed contribute to increased frequency of occurrence of lower and higher stream discharges. These variables exacerbate the delicate dynamics of the habitat components and fish reproduction in the Skagit River basin.

The Skagit River system supports major populations of anadromous fish, including five Pacific salmon species and trout, char, and sturgeon. The salmonid species include spring and summer/fall chinook salmon, *Oncorhynchus tshawytscha*; coho salmon, *O. kisutch*; pink salmon, *O. gorbuscha*; chum salmon, *O. keta*; sockeye salmon, *O. nerka*; steelhead trout, *O. mykiss*; cutthroat trout, *O. clarki*; Dolly Varden char, *Salvelinus malma*; and bull trout, *S. confluentus*. The other anadromous species is white sturgeon, *Acipenser transmontanus*. The river system provides spawning, rearing, and migration habitat for the respective life stages of these species in the study area and throughout the accessible reaches of the basin. Most of these migratory fisheries resources are the result of self-sustaining natural production. Hatchery fish culture does augment the production of spring and summer chinook, coho, and steelhead. Large populations of pink and chum salmon are the result of natural production in the basin. Recent year average production from this basin has been:

Skagit River Salmon Production[1]

		Data years
Spring Chinook	5,300	86-90
Summer/fall Chinook	49,800	85-89
Coho[2]	149,900	88-90
Pink	1,350,000	85-90
Chum,[3] even year	258,900	85-90
odd year	68,000	85-90
Steelhead[2]	16,800	81-91

1. Total catch and escapement, including Canadian catch.
2. Includes both hatchery and natural production.
3. Chum exhibit even and odd year variations in abundance attributed to interaction with pink salmon.

(Sources: Puget Sound salmon stock review group, 1992; Northwest Indian Fisheries Commission, Joint Objectives and Goals, U.S./Canada salmon treaty document, 1991; Chinook Technical Committee Report 92-4, U.S./Canada, 1992; WDW 1991.)

The chinook salmon are considered locally to occur as two discreet races, or stocks: spring and summer/fall, corresponding to their season of freshwater entry as adults. Spring chinook enter the Skagit River system in peak numbers in the months of May and June. They ascend the mainstem, dispersing to spawn in the upper Cascade River, the upper Sauk River, and the tributaries of the Suiattle River, spawning from late July through early September. This stock is now cultured in small numbers at the state hatchery at Clark Creek near Marblemount. Egg incubation lasts through the fall and winter, with juvenile emergence beginning as early as January, but probably not peaking until March. The young fish rear in freshwater for a few months or up to a year, with most of the smolts emigrating over a protracted spring outmigration, from March to July, peaking in May.

The summer/fall chinook begin entering the river in late June, with the peak of the run in the last week of July and first week of August, and some fish entering through the autumn. The peak period of spawning is in September. Spawning occurs in the mainstem from Lyman upstream to Newhalem and the middle and lower Sauk River, the Cascade River, and a number of the major tributary streams. This stock of fish is also cultured at the Clark Creek hatchery. Peak emergence of the summer/fall chinook is in March, and most of the juveniles undergo smoltification and outmigration in their first spring as sub-yearlings. Juvenile emergence occurs earlier at the hatcheries because of warmer thermal regimes, but the outmigration usually coincides with that of the naturally produced fish.

Significant numbers of coho salmon enter the river from late August through November, with the peak of the run coming in October. Coho spawn in all accessible tributaries, and peak spawning usually occurs in December. Coho are also cultured at the state and tribal fish facilities. Peak emergence of naturally spawned coho is in April, with the juveniles rearing throughout the river basin for one year prior to emigrating as yearling smolts in their second spring. The peak month for the coho outmigration is May.

Pink salmon return to the Skagit River in odd numbered years only, beginning their upstream migration in mid-August and lasting into October. Spawning usually begins by mid-September and is completed by late October. Pinks spawn in the mainstem from Lyman to Newhalem, the Sauk, the Cascade, and nearly all tributaries except the Baker. Juvenile emergence peaks in March and April. Young pink salmon are smolts at emergence, and immediately begin their downstream migration. Very few pink salmon are cultured in the Skagit basin.

Chum salmon enter the river in large numbers from October through December. Peak spawning is in December. Most spawning occurs in the mainstem and side channels and sloughs in the upper river upstream of Rockport. Significant numbers also spawn in the Sauk and Cascade Rivers as well. Juvenile emergence and outmigration occur in March through May. Like the pink salmon, juvenile chum do not rear very long in freshwater. Most of the chum salmon production is the result of natural production; few chums are cultured in the Skagit.

A depressed sockeye salmon run returns to the Skagit River each year at mid-summer to spawn in specially developed beaches in the Baker River system. This population appears to have been adversely affected at the smolt outmigration stage by the development and operation of hydroelectric facilities on the Baker River. The power company, state, federal, and tribal fisheries agencies are attempting to restore the sockeye population to viability. Juvenile sockeye are usually lake rearing obligates, and they rear in Baker Lake for one year before emigrating in their second spring. Most of the production results from natural rearing, however, some sockeye smolts are artificially reared each year as a part of the restoration program.

Four stocks of steelhead occur in the Skagit basin. Hatchery winter run steelhead enter the system primarily in December and into February, peaking either in December or January. Spawning usually occurs in January through March in the vicinity of release sites or collection facilities. Native winter run steelhead begin entering in January, and run entry timing extends through March. The native fish spawning is well distributed in the mainstem, all major tributaries except the Baker, and most minor tributaries from mid-March until early June, peaking in mid-May. A small run of summer steelhead also occurs in the Skagit, some hatchery and some native. They may enter as early as May and trickle in through September or October, but most would enter in June through August. Summer steelhead may be found anywhere in the accessible basin, but are most common in the upper mainstem, the upper Cascade, the upper Sauk, and selected tributaries. The summer run fish are believed to spawn in February and March in these upper headwaters and tributaries. Juvenile steelhead emerge from the gravel in June through August and rear throughout the basin for two, and sometimes three years, before smolting. Most steelhead smolts emigrate from mid-April through May.

Searun cutthroat may run in the Skagit over so broad a period as to seem resident, however, the main spawning run occurs from August through October. The fish are well dispersed in the mainstem up through the middle reach and its tributaries. Cutthroat spawning peaks in February or March, with the juveniles emerging in the late spring. Juvenile cutthroat, like steelhead, rear in freshwater for two or three years before migrating to saltwater in the spring.

Dolly Varden/bull trout char are quite common to the Skagit River system. They can be found in the river throughout the year, but the principle adult migration is in the late summer and early fall. Dolly Varden spawn in the upper accessible reaches of the major tributaries from September through November. Like steelhead and sea run cutthroat, juvenile Dolly Varden rear two or three years in freshwater prior to smoltification. The juvenile outmigration occurs in the spring.

All the Pacific salmon species die after spawning. The trout and char may survive, return to marine waters and make a subsequent spawning run. Post spawning steelhead kelts may return to salt water shortly after spawning, but cutthroat and Dolly Varden typically overwinter in freshwater and return to saltwater the following spring, often feeding on outmigrating pink and chum salmon smolts along the way.

Other migratory fish utilizing the Skagit basin includes white sturgeon. Information on this species and its numbers is limited. Sturgeon are sparsely distributed, and probably utilize only the lower river. They spawn in the spring and early summer, favoring sandy substrate for their spring spawning rather than the gravel that predominates further upstream.

Several resident fish species are also common to the river basin. The mainstem and various reaches of the forks and tributaries support resident rainbow and cutthroat trout, resident Dolly Varden and bull trout, whitefish, sculpins, large-scale suckers, peamouth, and dace.

The Samish River also produces important populations of anadromous fish. A major run of fall chinook salmon is supported by the state salmon hatchery on Friday

Creek. Natural production of coho and chum salmon in this basin account for about 18,000 and 2,500, respectively, each year. Steelhead, primarily a hatchery supported winter run, and cutthroat trout, each population numbering in the hundreds, are also present in the Samish.

TERRESTRIAL RESOURCES

The project study area traverses predominately agricultural lands interrupted by several towns and rural communities, as well as scattered rural residences, occurring singly and in clusters. Limited deciduous forest cover is found along the river within the study area, scattered between Mount Vernon and Sedro Woolley and along the lower forks. Most wildlife species typical of the region are found in or near the study area. Mammals include game species such as blacktail deer, as well as fur bearers like beaver, mink, muskrat, raccoon and river otters. Deer may be expected wherever forest browse and cover are nearby. The furbearing species occur throughout the study area. Rabbits and rodents are likewise common throughout the study area. Coyotes are abundant, and foxes may be found at some locations.

Numerous bird species are present, either as seasonal migratory species or year round residents. Several raptor species occur in the Skagit valley, including threatened and endangered ones like bald eagles and peregrine falcons. Wintering bald eagles commonly feed on spawned out salmon carcasses along gravel bars of the Skagit River, with the upper river outside the study area receiving the greatest eagle utilization. Other common raptors are red tailed hawks, northern harriers, kestrels, ospreys, great horned owls, and barn owls. A large number of passerine species are present in the study area, most of them seasonally. Waterfowl are more common to lakes, ponds, and marine waters, but they are important species in the study area as well. Trumpeter and tundra swans, Canada goose, snow goose, mallard, widgeon, teal, and other ducks occur there. The common merganser, blue heron, and ouzel, or dipper, are common year round residents. The belted kingfisher is found along all river reaches in the study area. Ruffed grouse are common to all deciduous forest areas, and introduced ring-necked pheasant occur near shrub and brushy cover, particularly near the wildlife management area on the south fork.

SITE SPECIFIC FISH AND WILDLIFE RESOURCES

ALTERNATIVE ONE

This alternative provides improvements to the existing levee system along the Skagit River from Sedro Woolley downstream to the mouth, including both forks. It also includes the development of a diversion structure between Sedro Woolley and Burlington and a bypass channel with an hydraulic capacity of 80,000 cfs. This channel would be routed north and merge with the Samish River where the managed channel would require increased hydraulic capacity to also accommodate the Samish and its concurrent floodwaters.

All of the fish and most of the wildlife resources common to the Skagit basin occur in and around this project alternative. Chinook, coho, pink, chum, and sockeye salmon, steelhead, cutthroat, and Dolly Varden migrate upstream and downstream through the project area. Some of the species utilize rearing habitat in the proposed project area as well. Wildlife species include all the previously described mammals and many of the passerine birds. Water oriented birds like blue heron, kingfisher, ouzel, and mergansers occur here. Waterfowl, including trumpeter and tundra swans overwinter here. Grouse are common to parts of the area. Red tail hawks, ospreys, peregrine falcons, and bald eagles are found seasonally and year round.

ALTERNATIVE TWO

Again, all the earlier described fish species migrate through this part of the study area. The Mount Vernon and Burlington urban areas would not be expected to support extensive wildlife populations, although deer and raccoons are sited fairly often. Terrestrial habitat is limited to urban backyards, agricultural land recently converted to commercial and residential development, and cultivated agricultural cropland. Passerines, wading birds, waterfowl, raptors, beaver, mink, and otter probably utilize the non urban area. The remainder of the alignment is on agricultural or recently converted farmland and probably supports some small rodents and other mammals.

THREATENED AND ENDANGERED SPECIES

The proposed project is in the normal range of wintering bald eagles. Bald eagles are listed by the federal government as a threatened species in the state of Washington. The Skagit River is known to provide significant habitat to the second largest concentration of wintering bald eagles in the lower forty-eight states because of important runs of spawning salmon, whose spent carcasses provide a ready source of food. The river corridor contains suitable perch trees and gravel bars for resting and foraging, while nearby coniferous forest stands provide night roosts. There are active nest sites along the river and elsewhere in the basin as well, but they are outside the project study area. Nesting peregrine falcons occur near the project area, and foraging by wintering falcons from January through March has been reported within the project area (Bud Anderson, Falcon Research Group, pers. comm.). Bull trout occur in the Skagit basin, and three other candidate species described on the attached species list may occur in the project area.

In accordance with Section 7(a)(2) of the Endangered Species Act of 1973, as amended, the Corps is required to assure that their actions have taken into consideration impacts to federally listed or proposed threatened or endangered species for all federally funded, constructed, permitted, or licensed projects. Therefore, the Service has enclosed a species list (Attachment A) as a response to Section 7(c) of the Endangered Species Act. If the proposed project requires the preparation of an Environmental Impact Statement, the Corps should prepare a biological assessment. Those responsibilities are described in Attachment B.

POTENTIAL IMPACTS TO FISH AND WILDLIFE RESOURCES

Project Alternative One appears to have the greater potential to adversely affect fish and wildlife resources of the Skagit and Samish River basins through imposition of the larger disturbance to the landscape and one of the rivers involved by constructing the flood bypass channel. It is not clear at this time how much of the disturbance would be temporal and how much might be permanent. Direct impacts from the bypass overflow structure should be limited to little more than the footprint, but it would probably be larger than existing levee structures. The bypass channel to the Samish River would involve major excavation of land that is presently rural residential and agricultural. The agricultural lands are extensively utilized by wintering waterfowl, including trumpeter and tundra swans. Depending on subsequent management of the bypass channel, continued availability for foraging waterfowl is a concern.

Setback levees paralleling the Samish River should not induce direct impacts to fish or wildlife, and they may provide wildlife habitat improvement opportunities through vegetation management. However, if clearing and grubbing of the Samish River riparian zone is necessary to improve flood water conveyance, then adverse habitat impacts will accrue to both fish and wildlife resources.

The proposed channel straightening of the Samish River at Allen would reduce habitat quantity by reducing channel segment length, and it may reduce habitat quality through removal of riparian vegetation and instream channel features.

Another effect of the proposed project would be from concentrating flood flows into a confined, managed channel. Under non-project conditions, overbank flooding would be spread over a larger area of the flood plain, eventually entering marine waters at several locations. A flood bypass channel would concentrate freshwater entry and sediment deposition off the mouth of the Samish River. A detailed assessment of these impacts would be the subject of project feasibility studies, but the Service is concerned about potential impacts to oyster culture in Samish Bay and to eel grass and crab resources.

There is insufficient information about the project to gage the net impact to fisheries at this time. Floods are usually negatively correlated to subsequent brood returns of salmonid fishes. Upstream migrations are inhibited by very high flows, and overbank flooding allows many adult fish to migrate out of the river channel and onto the floodplain where they may become stranded when the floodwaters recede. Offchannel storage creates refuges for juvenile fish from flood forces, but those areas may subsequently strand fish. Absent any significant off-channel refuge, juvenile fish are often washed out to marine water during floods. Most of the young fish are presumed to perish, since the majority are not seawater tolerant when winter floods occur.

The proposed project features would commingle Skagit and Samish River floodwaters at about a six year frequency and presumably the fish as well. This occurrence does not appear to differ significantly from historic conditions, but it would be more frequent than occurs under existing conditions with extensive levees on both river systems. The straying and eventual stranding of fish is an expected result, however, it does not appear possible to predict how much would be caused by the project. It is unclear if a project-induced adverse biological impact may accrue to the fishery. Fish may be lost to the intended spawning escapement, but that is a common occurrence as a result of flooding under existing conditions. Social and economic loss and displacement to important treaty and non-treaty commercial fisheries seem more likely.

Additional levee construction work along the river bank as a part of this project alternative may have the most potential to adversely affect fish. As we reported above, juvenile fish utilization of mainstem habitat is severely reduced in areas modified by flood protection measures such as levees and riprap. Although most of the project study area riverbank is already modified, the Service is concerned that additional habitat degradation might occur.

The urban ring dikes of the second alternative should impose few, if any, adverse impacts to fish and wildlife populations. The urban areas provide minimal wildlife habitat, and few impacts are anticipated. The urban levees may provide some opportunities for habitat improvement or development through vegetation plans. We anticipate that the ring dikes will include improvements to existing urban levees along the Skagit River. It is not apparent at this time that any unmodified streambank areas will be involved in this project alternative. This aspect of the project may have some potential to affect fish habitat through further streambank modification.

The overflow weirs associated with this project alternative may have greater potential affect fish and wildlife habitat, even though they will likely be located along streambanks that are already modified. The overflow weirs would have a much larger footprint than existing levees, and they could displace existing aquatic and terrestrial habitat. Further modification of existing levees may reduce already low aquatic habitat utilization. Wildlife foraging habitat may be lost to structural features of the overflow weirs.

RECOMMENDATIONS

The following are the Service's preliminary recommendations to avoid or mitigate potential adverse impacts to fish and wildlife resources. They are based on reconnaissance level information about the project alternatives and elements provided by the Corps. If the proposed project is modified during the feasibility phase, the Service may change its recommendations or make entirely new recommendations.

1. Prepare an inventory of all areas that could become project lands, and therefore, affected by the project.

2. Include an aquatic and terrestrial habitat assessment and evaluation of inventoried project lands.

3. Develop a fish and wildlife mitigation plan in cooperation with the Fish and Wildlife Service and state resource agencies.

4. Utilize setback levees rather than bankside levees. We normally prefer setback levees because bankside projects interfere with the natural processes that usually enhance, rather than degrade habitat features. However, we accept the inevitability that bankside levees are called for where major highways and towns are at risk.

5. Efforts should be made to protect and enhance any wetlands that may occur along or adjacent to proposed levee or overflow weir alignments.

6. Revegetate to pre-project conditions disturbed areas where vegetation has been removed or destroyed. Onsite plantings of native grasses, shrubs, and trees are preferred. The extent and degree of disturbance of vegetated areas should be kept to a minimum. In addition, revegetation efforts should occur in the first season following the disturbance. Construction equipment should be kept to areas where vegetation disturbance will be minimized.

7. Coordinate the construction season with the Fish and Wildlife Service and state and local regulatory agencies.

8. Avoid levee expansion construction activity on the riverward side of the existing levees.

9. Any required riprap work or additions should include large rock groins at the toe. This provides foundation material for bank armor and also may mitigate for lost fish habitat. These may be extended at selected locations to the surface elevations of flows up to about 18,000 cfs and vegetated to offset habitat loss due to levee construction.

10. Evaluate mitigation measures such as restoration of freshwater flow in diked off sloughs, such as Steamboat Island and Dry Slough on Fir Island.

11. A monitoring plan should be developed to determine the success of revegetation efforts, especially on erodible surfaces.

Should this project advance to the feasibility study phase, the Service will work with the Corps to develop a scope of work that will cover our participation in that phase as well as the preparation of the Fish and Wildlife Coordination Act report.

REFERENCES

Puget Sound salmon stock review group - WDF, NMFS, Puget Sound Treaty Tribes. 1992. An assessment of five stocks of Puget Sound chinook and coho as required under the PFMC definition of overfishing. Report to the salmon subcommittee of Science and Statistics Committee of the Pacific Fishery Management Council.

US/Canada Salmon Treaty. 1992. Chinook Technical Committee Report 92-4.

Northwest Indian Fisheries Commission. 1992. U.S./Canada Salmon Treaty. Joint Goals and Objectives Report, Chapter 9A - N, Review Draft.

Seattle District, Corps of Engineers. 1979. Skagit River, Washington. General Design Memorandum, Levee Improvements. Department of the Army.

U.S. Geological Survey, 1991. Water Supply Bulletin.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A Catalog of Washington Streams and Salmon Utilization, Volume 1. Washington Department of Fisheries.

Washington Department of Wildlife. 1991. Steelhead catch and escapement statistics.

ATTACHMENT A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES WHICH MAY OCCUR WITHIN THE VICINITY OF THE SKAGIT RIVER FLOOD DAMAGE REDUCTION STUDY, SKAGIT COUNTY, WASHINGTON

1-3-93-SP-321

LISTED

Bald eagle (*Haliaeetus leucocephalus*) - wintering bald eagles occur in the project vicinity from about October 31 through March 31.

Peregrine falcon (*Falco peregrinus*) - peregrine falcons occur in the project vicinity.

Major concerns that should be addressed in your biological assessment of the project impacts to bald eagles and peregrine falcons are:

1. Level of use of the project area by listed species.
2. Effect of the project on listed species primary food stocks and foraging areas in all areas influenced by the project.
3. Impacts from project construction (i.e., habitat loss, increased noise levels, increased human activity) which may result in disturbance to eagles and falcons and/or their avoidance of the project area.

PROPOSED

None.

CANDIDATE

Bull trout (*Salvelinus confluentus*) - occurs in the vicinity of the project.

California floater (mussel) (*Anodonta californiensis (Lea, 1852)*) - may occur in the vicinity of the project.

Northern red-legged frog (*Rana aurora aurora*) - may occur in the vicinity of the project.

Spotted frog (*Rana pretiosa*) - may occur in the vicinity of the project.

ATTACHMENT B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) AND 7(c) OF THE ENDANGERED SPECIES ACT OF 1973, AS AMENDED

SECTION 7(a) - Consultation/Conference

Requires:

1. Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species;

2. Consultation with FWS when a federal action may affect a listed endangered or threatened species to ensure that any action authorized, funded, or carried out by a federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the federal agency after it has determined if its action may affect (adversely or beneficially) a listed species; and

3. Conference with FWS when a federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or an adverse modification of proposed critical habitat.

SECTION 7(c) - Biological Assessment for Construction Projects *

Requires federal agencies or their designees to prepare a Biological Assessment (BA) for construction projects only. The purpose of the BA is to identify any proposed and/or listed species which is/are likely to be affected by a construction project. The process is initiated by a federal agency in requesting a list of proposed and listed threatened and endangered species (list attached). The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the species list, please verify the accuracy of the list with our Service. No irreversible commitment of resources is to be made during the BA process which would result in violation of the requirements under Section 7(a) of the Act. Planning, design, and administrative actions may be taken; however, no construction may begin.

To complete the BA, your agency or its designee should: (1) conduct an onsite inspection of the area to be affected by the proposal, which may include a detailed survey of the area to determine if the species is present and whether suitable habitat exists for either expanding the existing population or potential reintroduction of the species; (2) review literature and scientific data to determine species distribution, habitat needs, and other biological requirements; (3) interview experts including those within the FWS, National Marine Fisheries Service, state conservation department, universities, and others who may have data not yet published in scientific literature; (4) review and analyze the effects of the proposal on the species in terms of individuals and populations, including consideration of cumulative effects of the proposal on the species and its habitat; (5) analyze alternative actions that may provide conservation measures; and (6) prepare a report documenting the results, including a discussion of study methods used, any problems encountered, and other relevant information. Upon completion, the report should be forwarded to our Endangered Species Division, 3704 Griffin Lane SE, Suite 102, Olympia, WA 98501-2192.

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* "Construction project" means any major federal action which significantly affects the quality of the human environment (requiring an EIS), designed primarily to result in the building or erection of human-made structures such as dams, buildings, roads, pipelines, channels, and the like. This includes federal action such as permits, grants, licenses, or other forms of federal authorization or approval which may result in construction.